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BASIC PATENTS IN NATURE[1]

By WILLIAM K. GREGORY

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AT a time when the very word "adaptation" is anathema to many scientists it may seem reactionary to choose an even more anthropomorphic term such as "basic patents" to stand for the same idea. Nevertheless, as I shall try to show later, each one of us is able to carry on the business of life solely by means of our capital stock of Nature's patents, inherited from ancestors that have somehow gradually invented or come upon them in the long rise from fish to man. By basic patents I mean not only the things invented but the principles of construction and operation, of which Nature is the sole and rightful patentee; albeit many of her patents have been stolen from her by that Promethean rebel, *Homo sapiens,* who maintains to date a fairly successful revolt against her armies of other organisms that are perpetually waging war against him.

Here, however, we come at once into the midst of things. What are some of the reasons for this perpetual struggle and warfare which is the *vis à tergo* of evolution? The specific properties and reactions of water, carbonic acid, the atmosphere, and so forth, which collectively constitute the fitness of the environment for the support of life, appear to emerge from the interaction of still more elementary principles, such as the following: Nature is almost infinitely repetitious but variable. Her experiments are extended in time and her forces vary in intensity, duration and extent. From the recurrent clash of her cosmic forces the terrestrial environment experiences many cycles of day and night, of high tide and low tide, of summer and winter and the shifting of the poles, cycles of climate, cycles of mountain building and base leveling, of submergence and emergence. To all these the struggling populations of living organisms must adjust themselves or be crowded out.

These variable forces do not, however, wholly cancel each other; they leave cumulative results scat-

[1] Address of the president of the New York Academy of Sciences, given on December 18, 1933.

tered about for longer or shorter times. Hence it is no wonder that the organism which embodies a system of forces that are ultimately derived from the environment should develop and respond to the environment in a cyclical way, with corresponding accelerations and retardations of growth, with alternations of spending and storing up energy, *et cetera*.

In the Hall of the Natural History of Man, which we recently opened in the American Museum of Natural History, we have attempted to set forth some of the basic and subsequent patents of Nature by means of which the vertebrates have risen through grade after grade of structural advances.

In tracing the history of any of Nature's patents we ought logically to begin with the forces inside the hydrogen atom and work outward and upward through organic chemistry to man. But here the curator-in-charge had the excuse of lack of space. Since we had to begin somewhere we started with the sun as the source of terrestrial life and with man as a living solar engine, dependent upon the energy of the sun stored up in the green coloring matter of plants. Then it was easy to set forth, even if only in a very elementary way, the taking in of energy in the food, its digestion, its storage in the liver, its distribution by the blood stream, its utilization in the muscles and glands, its escape as heat, each adjustment involving a large number of Nature's inventions. In this exhibit human anatomy is visualized from its functional aspect and one's attention is thus directed to the mechanism of the "living bellows," including the diaphragm, to the "main pump" of the distributing system and to the "currency of the body," which is the blood corpuscles.

Relatively early stages in the evolution of these basic patents may be seen in such lowly vertebrates as the shark, where, as every young student in zoology soon learns, we meet remarkably primitive conditions of every system, so that, on the whole, the anatomy of the shark is practically an epitome of that of man.

One of the ways in which Nature builds up her new patents out of old ones may be illustrated in a brief comparison of the blood-vessels of the respiratory system in the shark with those of man. It is known to every beginner that in the shark the aortic arches that convey blood from the heart to the gills and from the gills to the body are five in number and that they are all much alike, and symmetrically arranged on either side of the midline; also that in mammals only one of these arches remains, that it is now of very large size and strongly asymmetrical, and that it serves a somewhat different function from that of the aortic arches of the shark. For the former condition, in which there is a series of several or many homologous parts all constructed and functioning alike, I have recently invented the name "polyisomerism," (from *poly*—many; *isos*—equal; *meros*—part); the latter condition, in which one or more of these parts become enlarged and asymmetrical, I have named "anisomerism." The development of polyisomeres in the individual normally takes place through processes that are analogous with budding, while anisomeres are usually lop-sided or uneven polyisomeres; although, as we shall see, anisomerism may often affect whole regions.

As another example, the dentition of a shark is highly polyisomerous. In the mouth of any ordinary shark you may see the crowding polyisomeres produced by the unchecked budding of the dental lamina; the dentition of man, on the other hand, is largely anisomerous, the teeth being few in number and much less like each other than they were in the earliest vertebrates. Thus one great triumph of Nature, by means of which she has been able to people the earth with myriads of organic forms, was the invention of adaptable polyisomeres and the subsequent modification of these into anisomeres.

The elements of the locomotor apparatus are likewise polyisomerous to a high degree. It is estimated that there are several billions of muscle fibrillae in the human body; these are integrated into a few million muscle fibers and these in turn into several hundred muscles. In the fish the red muscle fibers, stretched between septa, are arranged in W-shaped myomeres along either side of the backbone. These again are typical polyisomeres. It is by contraction of these elements, one after another, first on one side and then on the other, that a series of waves is set up, each wave passing down the backbone toward the tail and pushing the body forward. It is well known that traces of this primitive arrangement are found in the developing human embryo, in which, as shown in the Carnegie monographs on human embryology, the embryonic somites containing the tissue that gives rise to the axial muscles and to the backbone itself are seen as a series of small blocks in the position of the primitive myomeres of the fish. It is from these polyisomeres in the embryo that are developed the markedly anisomerous muscles of the human adult.

The evolution of the skeleton of vertebrates from fish to man tells a similar story of the transformation of primitive polyisomeres into specialized anisomeres. The vertebral column of the earliest fishes consisted chiefly of a continuous notochordal rod, highly polyisomerous in its microscopic make-up, surrounded by incomplete rings and surmounted by many similar slender rods.

Even up to the time of the early amphibians the axial skeleton shows only a gradual differentiation, or regional anisomerism, as we pass from the neck

backward to the tail. But as the first reptiles invaded the dry land and began to run about or to dig holes, the stresses on different parts of the column became more highly differentiated and strong local anisomerism resulted. For example, the sacral ribs, which were at first but little different from ordinary ribs, became greatly enlarged and anisomerous as they took on the function of transmitting the thrusts of the hind limbs to the column.

At the upper end of the series, in man, this tendency toward anisomerism, or differentiation of the regions of the backbone, becomes very marked, partly as a result of the new and difficult position in which the backbone finds itself, at right angles to its primitive horizontal position.

The concept of polyisomerism and anisomerism is well illustrated also in the story of the first appearance and rise of the paired limbs corresponding to our arms and legs. Among the earliest known fish-like vertebrates, the anaspid ostracoderms of Silurian times, the future paired fins were apparently represented merely by two rows of small projecting scutes on the ventral surface of the fish, which converged gradually toward the median ventral fins. These projecting scutes were evidently primitive and polyisomerous to a high degree.

In a higher stage, preserved in certain genera of acanthodian sharks of the Lower Devonian period, there were still present several pairs of accessory or intermediate paired fins lying between the pectoral and pelvic pairs. In other words, the paired fins of these later acanthodians were merely the anisomerous survivors reduced to two pairs of a former series of polyisomeres.

The same principle may be illustrated in the later history of the paired fins. In the fossil cladoselachian sharks the paired fins were exactly like the median or unpaired fins in that they were supported by polyisomerous series of cartilaginous rods, to which were attached the polyisomerous muscles of the body wall. In the course of time, however, anisomerism grew out of polyisomerism in the usual way by the enlargement of some of the series, the reduction and disappearance of others, and the coalescence of some of those that remained. In this way the base of the fin shortened and a mobile, wrist-like paddle which could turn on its own base was gradually evolved.

But at this point it is necessary to describe another basic process which has entered into the further evolution of paired paddles, as it has into many other patents of Nature. It is a very curious but abundantly attested fact that anisomeres may often begin to bud and thus give rise to polyisomeres of the second degree. Such, it seems, was the case in the paired fins, as evident in the leaf-shaped paddles of the earliest known lobe-finned and dipnoan fishes, which, according to weighty paleontological evidence, were closely related to the stem of the amphibians.

In the lobe-finned or crossopterygian ganoids the leaf-like paired fins had a central axis composed of budded anisomeres plus a diminishing row of marginal rods, perhaps remnants of the more primitive rods of earlier ages. Now until two weeks ago I had never been able to visualize in detail the probable steps by which the paddle of the lobe-finned fish became transformed into the five-toed hand of the primitive amphibian. One reason for my persistent inability to solve the problem was that in all earlier restorations of the lobe-finned fish the names applied to the upper and lower borders of the paddle were reversed. But as soon as this error was corrected by Professor Romer, of the University of Chicago, I set to work again on this classic problem and am now able to offer a new but apparently promising, if tentative, solution, as follows.

When the pectoral paddle began to be used as a fore limb, it was twisted on its axis and then turned downward in such a way that what is now the back of the hand was derived from that side of the paddle which then faced the surface of the body. In other words, when the whole fin was directed backward, the surface that would eventually give rise to our palms originally faced outward. The process of bending the paddle downward, then twisting it so that the outer surface gave rise to the palm, while the dorsally placed preaxial border became the thumb and the radius, is shown in a series of diagrams drawn under my direction by Mrs. Helen Ziska.

The origin of the carpal elements proved to be an almost insoluble puzzle, until I noticed that on the under side of the well-preserved skeleton of the Permian amphibian *Eryops megacephalus* Cope the small bones of the carpus were arranged in three obliquely curved series. Of these the first included the radiale, centrale 1 and probably the prepollex. The second series included four of the middle bones of the carpus, the third consisted of carpalia 1, 2, 3, 4, 5. Lines were then drawn delimiting these series. In the first series the amphibian carpus seems plainly to be represented in the lobe-finned fish by the small bones that lie on the dorsal or preaxial border and constitute the many-jointed secondary axis. The second or ulnar series not less plainly appears to be derived from the postaxial rods. The third series, or carpalia, had not yet appeared as such in the fish and was possibly represented by the epiphyses on the proximal ends of the fan-like rods that supported the distal portion of the fin and were to become the digits.

To derive the carpus of *Eryops,* then, from that of the lobe-finned fish, all that is necessary, in addition

to the twisting and down-turning of the fin, is the downward extension of the radius so that it becomes nearly equal in length to the ulna, and the consequent crowding and slight displacement of the postaxial rods, which would thus be shortened up into the numerous small bones of the middle of the carpus. The diagrams show how this would easily come about as a result of the predominant growth of the digital rays and the downgrowth of the radius.

In this way was evolved one of the most important basic patents ever worked out by Nature, namely, the five-rayed hand and foot, which is the basis of the decimal system. It only remained for man to invent the anisomerous dollar. I need not remind you that the pentadactylate hand and foot have been transmitted intact by the long line of vertebrate forms that culminated in man and we can safely eliminate from the probable line of ascent to man all the thousands of known vertebrates that show any loss of the five digits on each hand and foot or any undue specialization in the remaining digits.

Thus the concept of polyisomerism and anisomerism has led in many directions to a testing and confirmation of the general validity of the series of skeletons presented in the exhibit as illustrating the general progress from fish to man. Of course it is nowhere claimed that this series illustrates an absolutely continuous line of ascent. All that is maintained is that this series is the small residue after the elimination of thousands of other species of vertebrates which have become specialized further away from the direct line of ascent than the forms shown in this series.

To return to the paired limbs, the series as a whole illustrates a gradually increasing anisomerism, or differentiation, between the pectoral and pelvic limbs, both of which originated as locomotor organs. Here it is commonly recognized that the anisomeric development of the fore limb in man has somehow been associated with, or perhaps was the cause of, a change of function.

The change of primitive polyisomeres into anisomeres and the multiplication of anisomeres to form secondary or pseudo-polyisomeres is nowhere better illustrated than in the evolutionary history of the nervous system. In some of the oldest chordates, from the Silurian and Devonian of Norway and Spitzbergen, the mud that filtered into the brain-chamber and into the tunnels of the nerves and blood-vessels became petrified, leaving a permanent record of these parts. In this beautiful specimen figured by Stensiö, for example, we can see at once that regional anisomerism is already under way, so that the capsules of the olfactory, optic and otic organs are well differentiated. Nevertheless, the cranial nerves and blood-vessels retained to a hitherto unknown degree a condition of primary polyisomerism. In plainer terms, they are all much alike in their branchings in contrast to the highly differentiated condition in modern forms.

But I forbear to enter upon the details of the story of the evolution of the human brain, which has been so much illuminated by the contemporary researches of Kappers, Elliot Smith, Tilney and many others. I choose rather to stress the inquiry into the general way in which Nature works out her basic patents and some of the reasons why she has done so. I will even dare to put the question, Why have the nervous systems in general proved to be such successful inventions of Nature? It even seems possible to discern reasons why, from a zoological view-point, the human mind has come into existence.

This is the aspect of Nature's patents which is stressed in the labels of the closing sections of our new exhibits of the Natural History of Man.

Some years ago[2] I elaborated the following ideas: That all vital reactions are essentially anticipatory—the food must be secured and eaten before it can be digested and assimilated; the tooth grows under the gum before it erupts ready for use, the egg is fertilized and subdivided in anticipation, so to speak, of the adult that will grow out of the egg. Such reactions to future events are possible because the same environmental situations and the same internal needs and urges occur again and again. Now if a disagreeable pattern, A B C D, is unfolding, it would surely be an advantage if the organism could get out of the way quickly before the full consequences developed; if, on the other hand, E F G H I J K, etc., were a favorable sequence, it would normally be advantageous if the organism could appropriate it as soon as possible. Thus it would conceivably be advisable in the first instance for the organism to begin to move out of the way as soon as it received the first part of the signal, A, B, C, D, and in the second instance if it could move toward the object without waiting for the full signal. But it would be a still greater advantage if it had some arrangement whereby the bitter or sweet memories of past responses to such situations could further hasten the anticipatory reaction in the right direction in the well-known manner of the conditioned response.

Thus we see at once that the nervous system, even in the lowest organisms, not only shortens the time of reaction to present stimuli and to future results, but also makes possible the invention of memory and the utilization of experience. In other words, the habit of gambling in futures is by no means confined to

[2] "On Design in Nature," *The Yale Review*, January, 1924.

Wall Street but is a fundamental reaction of all organisms.

Now among the vertebrates there are two general types of central nervous systems and accompanying reactions: one, a very low type illustrated by the brain of the shark, the other, a very advanced type represented by the brain of man. And just as in other anatomical systems, the anatomy of the shark is practically an epitome of that of man, so in the case of the nervous system the shark's brain is, broadly speaking, the foundation upon which the human brain has been built. If we offer a shark a piece of salt pork on a hook he will probably snatch it without hesitation if he is hungry. This is paleokinesis, the more immediate response to sensory stimuli. If you offer a man a pork chop, however, he may refuse it because he is dieting, or for other reasons. This is neokinesis, which is, in plain terms, action controlled by ideas.

So too among other mammals with a neopallium the central nervous system has become above all else the great organ of anticipation. It is not enough to get out of the way when one is kicked. A neopallium enables one to jump aside just before the blow lands, or even to open hostilities with aggressive defense reactions of various objectionable sorts.

When beavers fell trees, build dams, lay in a stock of food and prepare excellent winter houses where they can live comfortably and defy the wintry blasts and sheeted ice, they represent a relatively high type of anticipatory reaction. Perhaps some of the wiser heads remember the chill of the previous winter; under the stirring memory of formerly empty bellies they start cutting down trees to encourage the others to begin in time. But to scientists, who dislike such anthropomorphic images, it seems nearer to the evidence to assume only that the relatively simple association systems of the beaver's neopallium supply the beavers with pleasant sensations whenever they work their jaws, push trees about, heap up the mud, and so forth, in the patterns that have proved most profitable to the race in the past. In other words, we must assume that the mechanism of heredity is so delicately geared that after millions of years it produces beavers that will react in those complex ways when they get the right stimuli, say from each other's presence, or from the nest-building instinct, or from the instinct to push logs against the stream and so forth.

Some thinkers may prefer to emulate the mystic philosopher of the bluebird and to postulate a grandfather beaver spirit, which presides over the society of the beavers and has successfully directed their endeavors since early times. If that be true, the grandfather beaver spirit must be the descendant of the *n*th great-grandfather spirit of *Eutypomys,* who was the physical ancestor of the beavers in Oligocene times. Thus we must reconstruct a family tree of beaver spirits paralleling that of their physical counterparts. Such dualism for beavers ought to appeal to all those who insist upon dualism in man.

In conclusion, to return now to the subject of basic and subsequent patents in Nature, it may be profitable first to list some of the features in which Nature's patents resemble human patents and then to examine the differences between them.

Both human and natural inventions are put together in such a way that they transform potential energy into mechanical work, work that is normally useful either to the maintenance of the individual or to the perpetuation of the race. Or they may act as a stimulus to the nervous system of organisms, causing them to react in ways profitable to the owners of the patents.

Since the mechanical and chemical conditions of the environment are much the same for both natural and human inventions, these two classes frequently adopt similar mechanical devices, such as the simple and compound lever, the cord, the lubricated groove and fulcrum, the arrangement of many similar motors, either in series or parallel, and so forth. The two kinds of invention are equally the product of evolution, that is, each stage grows out of earlier stages and both evolve through the principle of interest and compound interest in which the advantageous increments become cumulative with time. Both human and natural inventions are often constructed of a number of similar pieces, together with parts that are highly differentiated.

Both are not only anticipatory in action, but normally embody the results of a long line of trial and error. They are equally subject to the guiding force of selection operating in certain directions. They depend for their future success upon the regular recurrence or continuation of conditions that have been successfully met by similar arrangements in the past. In other words, they project past experience into the future. Human inventions, however, are products of the central nervous system, which has become the chief organ of anticipation. They project memory and experience, which have been perpetuated by tradition or written records, the human counterpart of heredity.

Perhaps the greatest difference between human and natural designs is that, whereas natural designs can change only by the slow modification of a single type, human designs commonly evolve also by a principle of cross-breeding or the conjunction of hitherto separate lines of development in one new complex organization. Thus the first steam locomotive was a hybrid between

a wagon and a steam-engine. These combinations are, however, paralleled to a certain extent in nature by the symbiosis of certain fungi and algae into lichens, or by the complex interactions of hosts and parasites.

Finally, it is not generally recognized that the human mind is, on the whole, such a successful device of Nature because it embodies to a high degree the anticipatory qualities which are essential to all life.

However, the resemblances between natural and human inventions are probably deceptive if they lead us to impute anthropomorphic qualities to Nature.

THE SEPARATION AND PROPERTIES OF THE ISOTOPES OF HYDROGEN[1]

By Professor HAROLD C. UREY

DEPARTMENT OF CHEMISTRY, COLUMBIA UNIVERSITY

As all chemists know, the atoms of the elements are not all precisely identical. Most of the elements consist of mixtures of two or more varieties of atoms having similar chemical properties but different atomic weights. In most cases, the chemical and physical properties of these isotopes, as they are called, are so nearly identical that it is very difficult indeed to detect any differences except those which depend upon mass directly. In the case of the hydrogen isotopes, however, the mass ratio is one to two, and this large difference gives rise to very appreciable differences in the physical and chemical properties. Because of these outstanding differences it has seemed desirable to name each of the isotopes, and we have proposed the name protium for the isotope of hydrogen having an atomic weight of one, and deuterium for that of atomic weight two. The exact atomic weights are 1.00778 and 2.01356, based upon a standard of O^{16} having an exact atomic weight of sixteen.

Since the heavier isotope of hydrogen was discovered about two years ago, some seventy-five papers and notes have been published dealing with its properties. It would be difficult to give an adequate review of the subject in the time available for this talk, and therefore I shall confine myself to a few topics which have interested us at Columbia, giving them in detail and referring only briefly to other interesting and valuable work. I shall discuss methods of separation and the properties of the hydrogens. The method of discovery is history now and need not be reviewed.

THE SEPARATION OF THE ISOTOPES OF HYDROGEN

Because of the large mass ratio of the two isotopes of hydrogen, all methods for separating isotopes should be more effective when applied to these isotopes than when applied to any others. In the past, isotopes have been separated slightly by fractional evaporation and fractional diffusion through porous solids. Mass spectrographs have separated very minute amounts of the isotopes of many elements, but the complete separation of two isotopes in any quantity has only recently been accomplished in the cases of neon and hydrogen. In the case of neon, the separation was secured by Hertz, using a diffusion method. The separation and properties of the hydrogen isotopes is the subject of the present discussion.

The first appreciable increase in concentration of the hydrogen isotopes was secured by the distillation of liquid hydrogen near its triple point. Calculations by Dr. Murphy and myself, based on the third law of thermodynamics and the Debye theory of the solid state, showed that such a distillation should be effective. The ratio of vapor pressures of $H^1{}_2$ and H^1H^2 over their pure solids at 13.95° A should be 2.37. How closely this was the case is not known, for the hydrogen used was electrolytic hydrogen and the isotopic composition unknown, but the effect was appreciable but probably smaller than expected from theory. In this way, samples containing the heavy isotope to the extent of about 1 part in 1,000 were prepared by Dr. F. G. Brickwedde, of the U. S. Bureau of Standards. At that time distillation of hydrogen seemed to be a logical method for concentrating the isotope, but due to the low surface tension of liquid hydrogen, it is difficult to prevent its escape as mist in a fractionating column. Such methods have not been successful.

Last year Dr. D. MacGillavry and I attempted the separation of the hydrogen isotopes by diffusing hydrogen gas across a flowing stream of mercury vapor. This gave a fractionation factor of 2.5. This is rather high, but the speed of the process is too low to make this method effective as compared with other methods.

The progress which has been possible during this year on the hydrogen isotopes is due to the discovery by Washburn and myself of the electrolytic method of separation. Dr. Washburn suggested the possibility

[1] Address before the New York Section of the American Chemical Society, December 8, 1933.

of separation by this method and we showed that the solutions in electrolytic cells contained higher concentrations of deuterium than natural water. Our first test was made spectroscopically, but subsequent density determinations showed that the density was greater than that of ordinary water by 60 parts per million, indicating a concentration of .0005 above the concentrations in ordinary water. Since this latter concentration is now known to be .0002, the concentrations in these electrolytic solutions is .0007 and the concentration has been increased by a factor of 3.5. In some cases the increase is even greater.

It is obvious, of course, that, by electrolyzing a large volume of water down to a small residual volume, the concentration of the deuterium can be increased without limit. The formula governing this electrolysis, if we assume that the fractionation factor does not change with the concentration of deuterium oxide, will be exactly that of the Rayleigh distillation formula:

$$\left(\frac{1-N_0}{1-N}\right)^{\frac{1}{\alpha-1}} \left(\frac{N_0}{N}\right)^{\frac{\alpha}{\alpha-1}} = \frac{W_0}{W}$$

where N_0 and N are the mole fractions of deuterium oxide in the initial water and the final residue, respectively, and W_0 and W are the initial and final volumes.

The following table shows the concentrations of deuterium oxide which can be secured by electrolyzing the water containing .0007 per cent. deuterium oxide down to different volumes, assuming that α, the fractionation ratio, is 6, as we have found for our laboratory cells. It will be seen that the method is quite effective for the separation of the isotopes.

N Mol. fract. of H^2_2O	W_0/W
.01	24.4
.10	393.5
.50	3054.0
.90	8531.0
.999	24280.0

This method was used by Dr. Washburn to secure samples of water containing a few per cent. of deuterium. It was on these samples that he discovered the difference in melting point and boiling point of the waters. This is also the method which Professor G. N. Lewis, of the University of California, has used for preparing the deuterium oxide in a practically pure state. This method has also been used by a number of other workers in the United States, and it is this method which is now being used by approximately ten or fifteen universities in the United States as well as a number in Europe.

The process which we are using at Columbia for carrying through this concentration is as follows. The first stages involve large-scale operations. We were fortunate to secure the cooperation of the Ohio Chemical Company who concentrated on a large scale the residual liquors which they have in their electrolytic cells. This work was carried on during the summer months and resulted in the preparation of water containing about ½ of 1 per cent. deuterium oxide. This help by the Ohio Chemical Company and particularly Mr. Rohrer, who carried it through, decreased the work which we must do in the further concentration, by about 75 per cent. and made available for other laboratories in the United States some 150 gallons of this water. Following this, Columbia University bought 50 gallons of the water, and Professors Zanetti, La Mer and myself and our coworkers have continued the concentration of the water in laboratory size cells.

The cells consist of a glass vessel with nickel tubing electrodes, so that the cell can be cooled by running water. In this way, it is possible to keep our cells operating at about 20° C., even with fairly high current densities flowing through the cell. The cells contain about 300 cc of potassium hydroxide solution and are operated at about 25 amp. current. Some 30 of these cells are placed in series across the 110 v. line. After the electrolysis has been carried down until the volume is about one third of the initial volume, the residual electrolyte is removed, ⅔ of the water is distilled from the potassium hydroxide and combined with the undistilled hydroxide. This material is then changed into other cells, which again carry the volume down to one third. Beginning with the second stage, the hydrogen and oxygen gases recombine, giving a condensate containing approximately .3 to .4 per cent. of deuterium oxide, and from this stage on, recombination of this kind is necessary. The gases of hydrogen and oxygen are burned through a nozzle, with the velocity of the flow of gas greater than the velocity of the flame, so that the flame does not strike back and cause the cells to explode. Explosion traps are placed between the cells and the nozzles so that, if an accidental explosion does occur, it does not break the cells.

In these laboratory cells, we have found that the fractionation factor is approximately 5 to 7, using these nickel electrodes. It does not vary greatly with current density, but decreases as the temperature increases, as though the difference in activation energy for the formation of H^1H^1 and H^1H^2 were 1,100–1,500 calories per gram molecule. The first stage produces 1 per cent., the second 2.2 per cent., the third 6.5 per cent., the fourth 16 to 20 per cent. and the fifth 40 per cent. deuterium oxide. At the present

time we are allowing this material to accumulate until we secure larger amounts before continuing the electrolysis. Since we are planning to produce about 400 cc of the heavy water, we do not wish to work with very small quantities of the water because of the ease of losing the material.

The cost of producing this heavy water in these high concentrations comes to about $15 or $20 per gram. This is in marked contrast to the quotations which we have seen in the public press of $150 a gram. Such prices are purely fictitious, for, at least using the methods which we have developed, the material can be prepared for much less than that. At present, we have approximately 280 cc of $H^2{}_2O$ in various concentrations, ranging from 1 per cent. to 99 per cent., with very appreciable amounts of the 16 per cent. and 40 per cent. material.

I might have exhibited here a number of samples in different stages of concentration, having filled all the bottles with ordinary water, for it would be quite impossible for you to tell the difference, but I do have a sample in this tube, and I can demonstrate that its freezing point is distinctively different from that of ordinary water. In the first place, we immerse the tube containing this deuterium oxide in an ice and water bath. This bath of course maintains a temperature lower than the melting point of pure deuterium oxide and hence it should freeze in this way. Due to the fact that the liquid supercools rather easily, it will not freeze readily under these conditions. I start the process by touching it for an instant to a piece of dry ice. This starts the crystals growing, and if you were nearer, you could see the long needles immediately shoot through the liquid. We will now immerse it in the ice and water bath for a period of ten minutes, and I think we will find that the material is frozen solid. Thus this sample contains a higher concentration of deuterium oxide than that which occurs in ordinary water, and we see here one of the physical differences between the light and heavy water.

The method of analysis of this water, which has been used largely up to the present time, is the determination of the density of the water, for it is to be expected that the volumes of the two varieties of water may be very nearly the same and thus that the ratio of the density of pure deuterium oxide and protium oxide should be the ratio of their molecular weights. In this way, it is possible to estimate the concentrations to a rather high degree of accuracy.

The method, however, is long and laborious, requiring very careful temperature controls in the thermostats and very careful weighing. Since the refractive indices of the waters are different, it is possible to use this as a method for analyzing the samples of water. Thus we find that a Zeiss interferometer may be used for analyzing our samples as soon as a relationship is established between the index of refraction and the density of the water. This method has been used by us for several months as a rapid method for following the increased concentrations of our deuterium, for it is possible to make an analysis within a few hundredths of a per cent. on samples running up to about 20 per cent. concentration in the course of about one hour. In this way, we are able to analyze the materials which are placed in our cells or which are removed, and so follow the course of the materials through the cells.

Properties of the Compounds Containing Protium and Deuterium

For our present purposes of discussion, we may classify the differences in properties of the compounds of the hydrogen isotopes under thermodynamic, physical, kinetic and physiological properties. Shortly after the discovery of the isotopes of hydrogen by Dr. Brickwedde, Dr. Murphy and myself, we made calculations to see what possible differences there might be in the thermodynamic properties of the two hydrogens and their compounds. Such calculations can be made, using the methods which have been established during the past ten years for securing the free energy, heat contents and entropies of diatomic gaseous substances, and the exact understanding of the structure of diatomic molecules, as revealed by molecular spectra.

Such calculations made for the reactions of hydrogen and chlorine and hydrogen and iodine show that small but appreciable differences in the free energy changes of the reactions could be expected, depending upon which of the two isotopes was used. Thus the difference in standard free energy change for the reactions:

$$H^1{}_2 + Cl_2 = 2\ H^1Cl$$

and

$$H^2{}_2 + Cl_2 = 2\ H^2Cl$$

should be about 408 cal. per gram molecule, which corresponds to a ratio of equilibrium constants for the two reactions of about 2 to 1 and a difference in the standard electrode potentials of about 9 millivolts. This, of course, would not be the electrode potential for the formation of aqueous hydrogen chloride from hydrogen gas and chlorine gas, because we do not know what differences in the solubilities of the hydrogen chlorides may exist, but it does give us an idea of the order of magnitude of the differences to be expected for such potentials. Similar calculations for the hydrogen iodide reactions showed that the ratio of equilibrium constants should be 1.222 at 700° K.

This difference is sufficiently great to make possible a test of the theory. Such experiments have been carried on in our laboratories by Mr. D. Rittenberg. In addition to ordinary hydrogen, Mr. Rittenberg has used samples containing higher concentrations of deuterium, thus being able to check the theory. Within the limits of experimental error, theory and experiment agree exactly. This, of course, is not as interesting as it would be if the experiments disagreed with the theory, but it is a great satisfaction to find that such a calculation is made possible by the progress that has been made in the fundamental understanding of the structure of atoms and molecules during the past quarter of a century. The calculation of this equilibrium constant was made and published months before the deuterium was prepared in a pure state. We may never be able to exactly calculate the equilibrium constant for the hydrogen iodide reaction without making any ordinary measurements on this equilibrium, but such checks as this at least give us the feeling that we understand pretty well the fundamental principles underlying such phenomena.

We have also secured very interesting results on this in connection with our studies of the equilibrium between the three varieties of hydrogen molecules, H^1_2, H^2_2 and H^1H^2. If we think of a bag containing protium and deuterium atoms and draw atoms from this bag to make up pairs of atoms to be represented as hydrogen molecules, we can easily show that the equilibrium constant for the reaction $H^1_2 + H^2_2 \rightarrow 2\ H^1H^2$ should always be 4. Thus the chance of drawing two H^1 atoms in succession is N^2, where N is the fraction of the total number of atoms which are protium atoms; and the chance of drawing two H^2 atoms in succession is $(1-N)^2$; while the chance of drawing first an H^1 and then an H^2 atom is $N(1-N)$ and the chance of drawing first an H^2 and then an H^1 atom is $(1-N)N$. Thus the relative abundance of the three types of molecules, $H^1_2 : H^1H^2 : H^2_2$, is $N^2 : 2N(1-N) : (1-N)^2$, and you will easily see that the equilibrium constant becomes equal to 4. An exact application of statistical mechanics to quantized systems such as these molecules shows that the equilibrium constant should not be exactly 4, but in fact at ordinary temperatures should be considerably less than that. The following table shows the calculated values for this equilibrium constant and also the experimental checks on this theory which we have secured in collaboration with Dr. Walker Bleakney, of Princeton. He is able to determine the relative abundance of the three types of molecules in a sample of hydrogen gas. He has been so kind as to analyze in this way samples of hydrogen which are the residual gases from the decomposition of our hydrogen iodide samples used to determine the equilibrium constants of the hydrogen iodide reactions. The third column gives the results of his determinations on these samples which we supplied to him.

EQUILIBRIUM CONSTANTS FOR THE REACTION
$H^1_2 + H^2_2 \rightleftarrows 2\ H^1H^2$

T	K (calc.)	K (obs.)
298.1	3.269	3.28
400.0	3.494	
575.0	3.710	
671.0	3.77	3.73
700.0	3.800	
741.0	3.82	3.75

It will be noticed that his equilibrium constants agree with the calculated values within the experimental limits of error in every case. Thus this check with the theory shows that we have secured equilibrium for our hydrogen iodide reaction at high temperature, for undoubtedly this equilibrium is established by the reaction of the hydrogen with the iodine to form hydrogen iodide molecules, and then these hydrogen iodide molecules react to give us hydrogen and iodine again. The whole system comes to equilibrium both with respect to the hydrogen iodide-iodine reaction and also with respect to the three varieties of hydrogen molecules. The second interesting point about this arises from the fact that Oliphant in England claims that heavy hydrogen gas confined over water disappears in the course of six weeks, showing that part of the heavy hydrogen has reacted with the light water, resulting in a mixing up of the hydrogen atoms in the gas and the hydrogen atoms in the water. This particular reaction was tried by Dr. Crist and Mr. Dalin at Columbia University about a year ago with negative results, though it may be of course that Oliphant had a catalyst present so that the reaction took place more rapidly. However, in the equilibrium between the three varieties of hydrogen molecules, such an exchange does not take place in the course of a few weeks because the samples of hydrogen which we prepared at 671° and 741° A were enclosed in glass flasks for several weeks at ordinary temperatures before Dr. Bleakney analyzed them. His tests showed that the equilibrium constant was still that characteristic of the high temperature and thus no very rapid exchange of atoms between the three types of hydrogen molecules had taken place in this length of time. At least we can say that not all exchange reactions involving the hydrogen atoms are so very rapid.

I think it is safe to predict that these calculations and experimental verifications indicate the order of magnitude to be expected in the differences of thermodynamic properties of the hydrogens and their compounds. Thus very appreciable differences in equilibrium constants, small differences in standard electrode potentials and in the standard free energy changes are to be expected through the whole field of chemical reactions involving hydrogen.

The differences in physical properties of the waters were not predicted by theory. Washburn first showed that the melting points and boiling points of a sample of water containing somewhat more than 1 per cent. of deuterium oxide had a distinctly higher melting point and boiling point than natural water. The differences were sufficiently large to be unmistakable. He further showed that the refractive index of this enriched water was distinctly less than that of natural water. Moreover, he followed this up by a distillation showing that the isotopes of hydrogen could be separated by fractional distillation. Following this, Lewis prepared what he considered to be practically pure deuterium oxide and determined its melting point as 3.8° C. and its boiling point as 101.4° C. He reports that the differences in the heats of vaporization of the two pure waters was about 269 cal. per gram molecule, the protium oxide having the lower value. In later work he has also shown that the separation of the isotopes by distillation effects a partial separation of the oxygen isotopes as well as the hydrogen isotopes. One can only admire the energy with which Lewis has attacked this problem and the skill he has shown in working with these minute samples. His values are undoubtedly of the right order of magnitude, but Professor La Mer and Dr. Eichelberger, from preliminary work in our laboratories, believe that the melting point given by Lewis is probably too low by about 0.5° and I think it probable that other constants reported must be revised.

It is interesting to consider one obvious but easily overlooked difficulty in working with this water. It must be very hygroscopic. Hygroscopic water! This is really something new! But you will see that nearly every molecule of atmospheric water that hits the surface of deuterium oxide will stick and, since this water is nearly pure protium oxide, will dilute it. The problem of overcoming this difficulty has prevented us from determining the density of our most concentrated samples, and our work on the purer material will be delayed until we have much larger samples, to avoid errors due to this effect. We are even considering a desiccated laboratory and the use of gas masks to prevent contamination of our water.

The following table records some of the differences in physical properties of H^2_2O observed so far:

PROPERTIES OF THE PROTIUM AND DEUTERIUM OXIDES

		H^1_2O	Mixture	(Per cent.)	H^2_2O
(1)	Density D^4_{20}	0.9982			1.1056
(2)	Refractive index n^D_{20}	1.33293	1.32849	(92)	(1.3281)
	n^C_{20}	1.33044	1.32683	(92)	(1.3265)
(1)	Molar refraction	3.711			(3.677)
(2)	Viscosity	10.87	13.7	(92)	(14.2)
(2)	Surface tension	72.75	88.1	(92)	(67.8)
(2)	Mag. susceptibility	− 0.72	− 0.65	(92)	
(2)	Molar susceptibility	−13.0	−13.0	(92)	
(3)	Equivalent conductances				
	$(H^{1+}$ in $H^1_2O)$	315.2	$(H^{2+}$ in $H^2_2O)$		213.7
	K+	64.2			54.5
	Cl−	65.2			55.3
(1)	B.P.	100° C.			101.42° C.
(1)	M.P.	0° C.			3.8° C.
(1)	ΔH_v	x			x + 259

(1) Lewis and MacDonald, *Jour. Am. Chem Soc.*, 55: 3057, 1933.
(2) Selwood and Frost, *Jour. Am. Chem. Soc.*, 55: 4335, 1933.
(3) Lewis and Doody, *Jour. Am. Chem. Soc.*, 55: 3504, 1933.

In addition to this, Taylor, Caley and Eyring have investigated the differences in solubilities of inorganic substances in 92 per cent. deuterium oxide, and they find that the solubility of these substances is markedly decreased by amounts of from 10 to 15 per cent. These investigations undoubtedly show something of the differences to be expected in physical properties of the hydrogens and their compounds. They are not large, but it is interesting indeed that we have here examples permitting us to see how they depend upon the mass of the hydrogen atoms present in the compounds. We may certainly expect that there will be a better understanding of both the solid and the liquid states resulting from a study of these properties, both experimentally and theoretically.

Up to the present time, sufficient work has not been done on the kinetic properties of the hydrogen isotopes to make possible anything but a brief discussion of theoretical arguments leading us to expect marked differences in the kinetics of the reaction. Undoubtedly the electrolytic separation of the hydrogen isotopes is itself an example of such a kinetic process. Unless the differences in electrode potentials are very much greater than those which are indicated by the calculations by Mr. Rittenberg and myself, we can not believe that the separation of the hydrogen isotopes is due to this cause.

Experiments which we have made on the temperature coefficient of the fractionation factor which are very preliminary indicate that the energy of activation for the process of the escape from the electrodes differs by approximately 1,100 to 1,500 cals., depending on whether it is an H^1_2 or H^1H^2 molecule which escapes. Eyring has suggested that the cause of this fractionation is due to this difference in the energy of activation, and the results which we have secured are of about the order of magnitude to be expected on the basis of his theory.

Newer theories in regard to the velocity of chemical reactions postulate with Arrhenius that there is a certain minimum energy of activation which is necessary for chemical reactions to go with finite velocity. Thus the average molecule at ordinary temperatures or the average pair of molecules at ordinary temperatures will not react, but must be raised to higher energy states before they will do so. In the case of the hydrogen isotopes, we could not at present say very much about the differences in energy between the activated molecules containing H^1 and those containing H^2. Thus the details of the excited states are beyond us at present, or at least this is certainly true so far as any detailed satisfactory discussion is concerned, but we do understand fairly well the unactivated energy states.

The principal difference between the compounds containing the heavy hydrogen and the light hydrogen will be in the zero point energies. This is a residual vibrational energy which the molecule does not lose, even at the absolute zero. It amounts to $\frac{1}{2}$ hν per molecule, where h is Planck's constant and ν is the frequency of vibration of the two atoms of a diatomic molecule relative to each other. The frequency ν depends upon the mass of the atoms of the molecule. Thus the ν's for the H^1_2 and H^2_2 molecules are in the inverse ratio of the square roots of the atomic weights. Hence, it must follow that the residual vibrational energy of the H^2 molecule is less than that of the H^1 molecule, and the calculated difference amounts to 1788.9 cals. per gram molecule. In order for the H^2_2 molecule to react, it must acquire this amount of energy more than the amount required for the H^1_2 to react, on the assumption that no other differences enter in, which is probably not exact. This difference alone will lead us to expect that the relative velocities will be in the ratio $\exp \frac{1788.9}{RT}$, which amounts at 700° K to 3.6. In addition to this effect, there are fewer collisions between the heavy molecules of a gas, other things being equal, which also favors the higher velocity of the reaction of the H^1_2 molecules.

The physiological differences between the compounds of the two hydrogens may be of very great importance in physiological studies. Professor Lewis has found that tobacco seeds did not sprout in this water, and Professor Taylor and his coworkers at Princeton have found that animals will not live when placed in the higher concentrations of the deuterium oxide.

The causes for these effects are not entirely clear, but from our own studies in regard to the differences in equilibrium constants, we believe it possible that the ionization constant for the deuterium oxide may be quite different from that of protium oxide. This would have a very marked effect upon living organisms.

In addition to this, the velocities of reactions within living organisms involve hydrogen atoms to a large extent, and since the velocities of chemical reactions may be markedly different, depending upon which isotope is used, it would not be at all surprising if the nice balance of chemical reactions taking place in living organisms would be disturbed to such an extent that life would be impossible. It will be interesting indeed to see whether animals can be acclimatized to the new water.

As to the question of possible industrial uses, no safe predictions can be made. Witness the uses for such substances as neon and argon! New methods of concentrating deuterium may be discovered, materially reducing its cost. The intense research activity here and abroad is likely to result in uses for it. Perhaps it will be as valuable as a by-product of the hydrogen and oxygen electrolytic plants as argon and neon are of the liquid air plants.

OBITUARY

FREDERICK LINCOLN CHASE

FREDERICK LINCOLN CHASE was born at Boulder, Colorado, on June 28, 1865, the son of George Franklin and Augusta Anne (Staples) Chase. He was graduated, A.B., at the University of Colorado in 1886 and was called to Yale Observatory as assistant astronomer in 1890. In 1910 after the retirement of Dr. Elkin from the directorship on account of ill health, Chase succeeded him with the title acting director; but his own health failed soon thereafter, and in 1913 he resigned his post and retired to his farm in Colorado, where he lived until his death on November 9 of this year.

Chase was an unusually able observer. In collabo-

ration with Dr. Elkin and with Mr. Mason Smith he determined with the heliometer the parallaxes of more than two hundred stars, and this at least doubled our direct knowledge at that time of stellar distances. By far the greater part of this observing was done by Chase himself, who for a period of twenty years observed on nearly every favorable night. It is well recognized that the heliometer is one of the most difficult and exacting instruments that the astronomer has been called upon to use.

In addition to his work on stellar parallaxes Chase published a valuable Triangulation of the Victoria Comparison Stars in connection with Gill's determination of the solar parallax from the observation of asteroids; a Triangulation of the Stars in the Cluster Coma Berenices; and a painstaking and conclusive research as to the effect of color on heliometer measures.

In recognition of these and other contributions the French Academy of Sciences conferred jointly upon Elkin, Chase and Smith their Lalande Medal in 1908.

Chase was exceedingly fond of athletics and outdoor life. He was an expert tennis player, especially at doubles; with one of his colleagues at Yale he several times won the Connecticut State Championship. Next to astronomy his chief passion was farming. One year when he was in charge of Yale Observatory he plowed up about five acres of the Observatory plat and sowed it in wheat. He did not get much of a return from this adventure except, as he laughingly said, "the fun of doing it." Both in Connecticut and Colorado he hunted on every occasion that he could, and, in fact, it was while hunting that death overtook him. He was found on the evening of November 9, in the shallow waters of a lake near his home, where he had succumbed a few minutes before to a heart attack.

Chase never married. The nearest relatives who survive him are cousins. His father had died a few years ago, and his mother still more recently. A Colorado friend writes of him, "I never saw a more devoted son than he was to his father and mother, both of whom lived to advanced ages."

Chase expressed some disappointment towards the end of his life as to the value of his arduous labors on stellar parallaxes, expressing the view that his results had been superseded by the more accurate photographic methods that followed. But his colleagues saw much more clearly than he did the pioneer rôle he had played, a rôle that helped to make possible the development of more accurate methods.

FRANK SCHLESINGER

RECENT DEATHS

DR. LYMAN CHURCHILL NEWELL, professor of chemistry at Boston University, died on December 13, at the age of sixty-six years.

DR. JOHN MERRILL POOR, professor of astronomy at Dartmouth College and head of the Shattuck Observatory, died on December 11. He was sixty-two years old.

PROFESSOR ALLISON W. SLOCUM, for thirty-nine years professor of physics at the University of Vermont, died on December 10, at the age of sixty-seven years.

JOSEPH L. MAYER, chief chemist of the Louis K. Liggett Company for more than twenty years and head of the department of chemistry of the Brooklyn College of Pharmacy, died suddenly on December 1, at the age of fifty-eight years.

DR. CLOYD N. MCALLISTER, professor of psychology and head of the Normal School at Berea College, died on October 31, at the age of sixty-three years. He had been at Berea for twenty years.

JAMES H. GIBBONEY, chief chemist of the Norfolk and Western Railway, died at his home, Roanoke, Virginia, October 31, 1933, at the age of fifty-four years. He was analyst for some time for the Virginia Geological Survey.

PROFESSOR ERWIN BAUR, director of the grain experimental station of the Kaiser Wilhelm Institute at Müncheberg, near Berlin, died on December 3, at the age of fifty-eight years.

SCIENTIFIC EVENTS

QUARANTINE AGAINST THE DUTCH ELM DISEASE

SECRETARY OF AGRICULTURE WALLACE has announced the establishment of a new quarantine, effective from October 21, designed to prevent further introductions of the Dutch elm disease from Europe. Following the apparently successful efforts made in Ohio to eradicate the few cases of this disease which cropped up there in 1930, the disease suddenly increased last summer, when an outbreak of considerable intensity was discovered in the environs of New York City, principally in northern New Jersey.

According to a bulletin issued by the U. S. Department of Agriculture:

Almost simultaneously with this development, it was found that elm burl logs were being imported into this country from Europe for the manufacture of veneer. Examination of these logs disclosed the presence in

some shipments of the Dutch elm disease fungus, and all the eight shipments entering since July 25 of this year were found to be more or less heavily infested with elm bark beetles, insects known to be important means of spreading the disease in Europe, where the disease has been distributed widely during the last decade and, on a large scale, has destroyed or seriously damaged elm shade trees.

With the willing cooperation of the importers of these logs, all shipments so far entered since this discovery have been treated in an attempt to safeguard them against escape of the insect carriers, and prompt action has now been taken by the Department of Agriculture to guard against future danger.

Secretary Wallace notes that the new quarantine seeks to close as effectually as possible every avenue to the entrance of the disease but at the same time seeks not to hamper any trade movement that could be permitted with safety. Under this quarantine, elm burl logs are to be allowed entry under permit with regulations providing that they arrive in this country free from bark so that no dangerous insect carriers of the fungus can be introduced with them. The regulations further require a hot water or other approved treatment to destroy any of the Dutch elm disease fungus that might be present in the logs.

In view of the important part which these elm bark beetles are said to play in spreading the fungus from dead or dying elm wood to living trees, the quarantine also stipulates that all lumber, timber, crates, boxes or other containers and manufactured articles derived from the wood of elm and related plants entering this country from Europe must be free from bark.

THE CALIFORNIA WILD LIFE ADMINISTRATION AND PEST CONTROL COMMITTEE

PROVIDED by the last California Legislature, the Wild Life Administration and Pest Control Committee held its first meeting at the University of California on December 19. This committee, established by authority of Senate Concurrent Resolution No. 26, includes representatives of all groups interested in the wild life of the state, its administration and control.

This committee grew out of an investigation inaugurated by President Robert G. Sproul within the university, to determine the basis of discord that existed among various agencies dealing with the many phases of wild life control and administration. The committee, in its report, suggested the formation of such a committee as that now provided, to act as a clearing house for controversial questions that arise, so that the administration of wild life may be harmonious and necessary control measures agreed upon for the benefit of the state.

The organizations, designated by the resolution, have appointed representatives as follows: State Department of Public Health, Edwin T. Ross; State Division of Fish and Game, John L. Farley; State Department of Agriculture, W. C. Jacobson; State Association of Agricultural Commissioners, Gordon Laing, Alameda County; Agricultural Department, State Chamber of Commerce, R. N. Wilson; Conservation Department, State Chamber of Commerce, Charles G. Dunwoody; Zoology Division, University of California, C. A. Kofoid; Pharmacology Department, Medical School, University of California, C. D. Leake; Hooper Foundation for Medical Research, University of California, Karl F. Meyer; College of Agriculture, University of California, T. I. Storer, Davis.

Other groups to be represented, but which have made no appointments as yet, are the United States Biological Survey, California Academy of Sciences, California Farm Bureau Federation, Cooper Ornithological Club and a state-wide sportsmen's organization. In addition, these representatives will name three members-at-large.

INTERNATIONAL MATHEMATICAL CONGRESS MEDALS

EVERY four years there is held an international gathering of mathematicians, known as the International Congress of Mathematicians. At the next meeting, to be held in Oslo in 1936, two Gold Medals will be awarded to mathematicians selected for their outstanding contributions to mathematics by an international committee appointed for the purpose. The foundation of these medals is due to the efforts of the late Dr. J. C. Fields, F.R.S., research professor of mathematics at the University of Toronto. Dr. Fields was responsible for assembling the Mathematical Congress in Toronto in 1924—the only meeting which has been held on this continent. He was president of the congress and the editor of its *Proceedings,* which constituted two large volumes, published by the University of Toronto Press. With funds remaining after the completion of the work, Dr. Fields suggested the foundation of these medals, as a Canadian contribution to the cause of international scientific cooperation, which he always had much at heart. Unfortunately Dr. Fields did not live to see the realization of his scheme, as he died in August, 1932, a month before the meeting of the Congress in Zurich, which gave international approval to the foundation of the medals. The medals will be awarded at each International Congress of Mathematicians in future.

In spite of the fact that the medals are of Canadian origin and are due to the personal efforts of Dr. Fields, it was his particular wish that in design and award they should be truly international in character, and should not be associated with any country or person. The task of designing a suitable medal was entrusted to the distinguished Canadian sculptor, Dr. R. Tait McKenzie, R.C.A., who has now completed his work.

The medal is two and a half inches in diameter.

The obverse shows the head of Archimedes facing right. As there are no authentic portraits of this perhaps greatest of all mathematicians, recourse was had to the fine collection of over thirty pictures collected by Professor David Eugene Smith, and placed by him in Columbia University. They show the ideas of as many artists, ancient and modern, of what his appearance may have been.

AWARD OF THE EDISON MEDAL TO PROFESSOR ARTHUR E. KENNELLY

THE Edison Medal for 1933 has been awarded by the American Institute of Electrical Engineers to Dr. Arthur E. Kennelly, "for meritorious achievements in electrical science, electrical engineering and the electrical arts as exemplified by his contributions to the theory of electrical transmission and to the development of international electrical standards."

The Edison Medal was founded by associates and friends of Thomas A. Edison, and is awarded annually for "meritorious achievement in electrical science, electrical engineering or the electrical arts" by a committee consisting of twenty-four members of the American Institute of Electrical Engineers.

The following eminent engineers and scientific men have been recipients of the medal: Elihu Thomson, Frank J. Sprague, George Westinghouse, William Stanley, Charles F. Brush, Alexander Graham Bell, Nikola Tesla, John J. Carty, Benjamin G. Lamme, W. L. R. Emmet, Michael I. Pupin, Cummings C. Chesney, Robert A. Millikan, John W. Lieb, John White Howell, Harris J. Ryan, William D. Coolidge, Frank B. Jewett, Charles F. Scott, Frank Conrad, Edwin W. Rice, Jr., and Bancroft Gherardi.

Arthur Edwin Kennelly was born near Bombay, India, December 17, 1861. Coming to the United States in 1887, he was engaged as principal electrical assistant to Thomas A. Edison until 1894, when he became associated with Edwin J. Houston in the firm of Houston and Kennelly, consulting electrical engineers.

He was appointed professor of electrical engineering at Harvard University in 1902 and continued in that position until the close of the academic year 1929–30, when he retired from active service. In addition to his work at Harvard, he served as professor of electrical engineering at the Massachusetts Institute of Technology from 1913 to 1924 and was for some years director of electrical engineering research there, as well as chairman of the faculty. During the year 1921–22, he represented seven cooperating American universities as first exchange professor in engineering and applied science at several French universities.

Dr. Kennelly has published about twenty-eight books, of which he is sole author of ten, including: "Theoretical Elements of Electro-Dynamic Machinery," "Wireless Telegraphy," "Electrical Vibration Instruments," "Electrical Lines and Nets" and several on hyperbolic and other complex functions. He is the author of more than 350 papers, many of which were presented before leading technical and scientific organizations in the United States and abroad, and have been widely distributed in technical publications.

One of his chief contributions to applied science is a paper on "Impedance" presented in 1893 before the American Institute of Electrical Engineers, containing the first use of complex numbers as applied to Ohm's Law in alternating-current engineering. He has also presented numerous other papers on the same general subject, many of which contain the first applications of complex hyperbolic angles to the problems of power and communication engineering and to artificial networks. Dr. Kennelly, in 1902, expounded a theory on the influence of a conducting layer in the atmosphere on long-distance radio transmission, which has since been verified experimentally and has resulted in the naming of the so-called ionized layer of reflection the Kennelly-Heaviside layer.

ENGINEERING AT THE BOSTON MEETING

THE program of Section M at the December meeting of the association will be of unusual interest and particularly appropriate in view of the current of national affairs at the present time and the attention which is being focussed on the farm problem. The first of the two most important features of the program is an evening lecture on Friday, December 29, by the Honorable Henry A. Wallace, Secretary of Agriculture, on "What Can Engineers Do for Agriculture?" On the following morning there will be a symposium on the general subject for which Secretary Wallace's address on the previous evening will serve as an introduction. Dr. Charles F. Kettering, chairman of Section M, will preside at this symposium, which will be a joint session of Sections M, K and O. It will be opened by the address of Professor D. C. Jackson as retiring chairman of Section M.

Because of the prominent part which the agricultural problem is occupying in the Administration's Recovery Program, it is particularly appropriate at this time to consider the engineer's part in the farm problem. A discussion of the ideas which are put forth at this symposium should result in an increasing recognition on the part of engineers of their responsibility in connection with our national problems generally and our agricultural problem in particular. The arousing of interest and active consideration of such a problem should tend to bring about a greater sympathy and understanding between the engineer and the farmer.

SCIENTIFIC NOTES AND NEWS

PROFESSOR ROGER ADAMS, head of the department of chemistry at the University of Illinois, has been elected president of the American Chemical Society for 1935. On January 1, Dr. Charles L. Reese, retired chemical director of E. I. du Pont de Nemours and Company, Inc., Wilmington, Delaware, will become president, serving through 1934. He succeeds Professor Arthur B. Lamb, of Harvard University, president for 1933.

ACCORDING to a United Press dispatch from Vatican City, Dr. George David Birkhoff, professor of mathematics at Harvard University, has been awarded a prize of 10,000 lire ($825) donated by Pope Pius XI in an international competition for the best book on "Systems for Solution of Differential Equations." The award was made during exercises inaugurating the new Pontifical Hall of Science on December 17.

DR. DEXTER S. KIMBALL, dean of the College of Engineering at Cornell University, on December 6 was awarded the Worcester Reed Warner Medal of the American Society of Mechanical Engineers for distinguished contributions to the field of industrial economics. Dean Kimball recently received the Lamme Medal of the Society for the Promotion of Engineering Education.

THE Planck Medal has been awarded to Dr. Werner Heisenberg, professor of theoretical physics at Leipzig.

DR. KARL SUDHOFF, professor of the history of medicine and of the natural sciences at Leipzig, celebrated his eightieth birthday on November 26.

THE following have been elected foreign members of the Geological Society of London: Professor Ray S. Bassler, of the U. S. National Museum; Dr. Arthur L. Day, of the Geophysical Laboratory, Washington; Professor Carl F. Kolderup, of the University of Bergen. The following foreign correspondents were also elected: Professor Michele Gortani, of the Royal University of Bologna; Dr. J. S. Lee, of the National Research Institute of Geology, Shanghai; Professor F. L. Ransome, of the California Institute of Technology, and Professor H. Yabe, of the Tôhoku Imperial University, Sendai, Japan.

AT the opening ceremonies of the academic year at the University of Montpellier, France, the degree of doctor *honoris causa* was conferred on Professor Douglas Johnson, professor of physiography at Columbia University.

THE degree of D.Sc. was conferred on Professor Arthur Thomson, who is shortly resigning from Dr. Lee's chair of anatomy, at the convocation of the University of Oxford on November 28.

THE University of Strasbourg has conferred the degree of doctor *honoris causa* on Dr. P. Zeeman, professor of physics at the University of Amsterdam.

THE Faculty Board of Physics and Chemistry of the University of Cambridge has appointed Professor W. Heisenberg, of the University of Leipzig, to be Scott Lecturer for 1934, and Professor G. von Hevesy, of the University of Freiburg, to be Scott Lecturer for 1935.

PROFESSOR WILLIS LINN JEPSON, of the department of botany of the University of California, has been appointed faculty lecturer for 1934. Appointment as faculty research lecturer at the University of California is the highest recognition that members of the faculty can give to one of their number for his contributions to knowledge.

THE *Journal* of the American Medical Association reports that Dr. Max A. Goldstein, founder and director of the Central Institute for the Deaf, St. Louis, was recently presented with the second annual St. Louis Award "in recognition of his achievements and research in dealing with the problems of the deaf." The award, $1,000 in cash and a certificate, is made each year to "the resident of metropolitan St. Louis who contributed the most outstanding service to the development or performed such service as to bring honor to the community."

IN celebration of the twenty-fifth anniversary of his coming to the faculty of the University of California, Professor W. B. Herms, professor of parasitology and entomologist in the experimental station, was recently given a banquet. More than 115 guests attended the celebration, which was arranged by the members of the division of entomology and parasitology. Professor E. O. Essig presided as toastmaster, and the speakers represented various activities in which Professor Herms is interested. At the close of the program he was presented with a portfolio bound in silver, containing 150 letters of greeting from former pupils and colleagues. On behalf of the guests Miss Florence M. Frost presented Mrs. Herms with a silver coffee service.

ALBERT E. MARSHALL, a consulting engineer of New York City, was elected president, and Dr. Harry A. Curtis, Knoxville, Tennessee, chief chemical engineer of the Tennessee Valley Authority, was elected vice-president of the American Institute of Chemical Engineers at their twenty-sixth annual meeting held on December 12 at Roanoke, Virginia.

DR. J. V. N. DORR, president of the Dorr Company, was elected president of the Chemical Engineering

Equipment Institute at its first annual meeting recently held at The Chemists' Club, New York. H. D. Miles, president of the Buffalo Foundry and Machine Company, who has served as president of the institute during its formative period, was elected vice-president of the organization for the fiscal year 1933–34.

DR. R. E. ROSE, director of the Technical Laboratory of E. I. du Pont de Nemours and Company, Inc., was reelected president at the recent annual meeting of the American Association of Textile Chemists and Colorists.

AT the anniversary meeting of the Mineralogical Society, London, held on November 9, Sir Thomas Holland was elected president and Sir William H. Bragg and Mr. Arthur Russell were elected vice-presidents.

THE following officers were elected at the annual general meeting of the London Mathematical Society held on November 16: *President,* Professor G. N. Watson; *Vice-Presidents,* Professor A. C. Dixon, Professor G. H. Hardy, Professor G. F. J. Temple.

DR. SHIRLEY W. WYNNE, commissioner of health of New York City since 1928, will retire on December 31.

DR. WALTER ALBERT JESSUP, president of the State University of Iowa, has been appointed president of the Carnegie Foundation for the Advancement of Teaching to succeed the late Dr. Henry Suzzallo.

HENRY ALBERT HARRIS has been elected professor of anatomy at the University of Cambridge as from October 1, 1934, in succession to Professor J. T. Wilson, fellow of St. John's College, who will retire on that date.

H. E. TUNNICLIFFE, Gonville and Caius College, Cambridge, has been appointed university lecturer in the department of physiology for three years. Dr. G. A. Millikan, Trinity College, son of Dr. Robert A. Millikan, has been appointed university demonstrator for the same period.

THE title of emeritus professor of psychology in the University of London has been conferred on Dr. Beatrice Edgell, on her retirement from the professorship of psychology at Bedford College.

DR. RAYMOND FUESS, National Research Council fellow now at the University of Leipzig, has been appointed assistant professor of chemistry at Brown University.

DR. CHARLES H. HERTY has been appointed a deputy administrator in the National Recovery Administration and assigned to Division 3, in charge of codes for the chemical industries.

Industrial and Engineering Chemistry reports that Louis Ehrenfeld has joined the staff of the Wahl-Henius Institute of Chicago in the capacity of assistant to the director. He has resigned his full-time work with the Museum of Science and Industry in Chicago, but is continuing his connection with it as curator of chemistry and is devoting a portion of his time toward directing the activities of the chemistry department, which was formerly under his active management.

DR. ROSS G. HARRISON, Sterling professor of biology at Yale University, delivered the third Harvey Lecture of the season at the New York Academy of Medicine on December 14. His subject was "Heteroplastic Grafting in Embryology."

DR. HERBERT M. EVANS, of the University of California, will give the fourth course of the Morris Herzstein Lectures. The lectures, under the provisions of the will of the late Dr. Morris Herzstein, of San Francisco, are held under the auspices of the University of California and of Stanford University. This year they will be given at San Francisco on January 29 and 31 and February 2. Dr. Evans, who is Morris Herzstein professor of biology and director of the Institute of Experimental Biology in the University of California, will speak on "The Internal Secretions of the Anterior Lobe of the Pituitary Gland."

DR. WILLIAM K. GREGORY, professor of paleontology at Columbia University and curator of comparative anatomy and ichthyology at the American Museum of Natural History, will read a paper on "A Half Century of Trituberculy, the Cope-Osborn Theory of Dental Evolution" before the stated meeting of the American Philosophical Society, Philadelphia, on January 5 at 8:15 P. M.

DR. EDWARD WIGHT WASHBURN, chief chemist of the Bureau of Standards, delivered a lecture on December 6 before the District of Columbia Chapter of the Society of Sigma Xi on "Heavy Water."

DR. G. KINGSLEY NOBLE, curator of herpetology and experimental biology in the American Museum of Natural History, spoke on December 8 before a meeting of the Westchester Institute of Sciences held at the Boyce Thompson Institute for Plant Research, on "The Biology of Animal Courtship."

THE annual Gross lecture of the Pathological Society of Philadelphia was given on the evening of December 14 by Dr. Alwin M. Pappenheimer on "Certain Nutritional Disorders of Laboratory Animals."

SIR JAMES JEANS will give the six Children's Christmas lectures this year at the Royal Society of

London. The title of the series is "Through Space and Time."

THE course of twelve Swiney lectures of the British Museum of Natural History is being given this year by Dr. R. M. Craig, of the University of Edinburgh. The general subject is "Geology in the Service of Man."

PROFESSOR KERR GRANT delivered his presidential address on "The Place and Value of Physical Science in the Modern State" at the fourth conference of Australian physicists and astronomers, which was held in Melbourne from August 15 to 18.

SIGMA PI SIGMA, honorary physics society, will this year hold its annual mid-winter luncheon at the Hotel Continental, Cambridge, Massachusetts, at 12:30 on Friday, December 29.

AT the September meeting of the International Association of Scientific Hydrology an International Commission on Snow was organized and the two commissions on snow and glaciers were requested to delimit the fields of activity for each. Professor Dr. Paul Mercanton, of Lausanne, Switzerland, is the new president of the International Commission on Glaciers. Dr. J. E. Church, of Haverford College, was selected as president and organizer of the new commission on snow. The personnel will not be selected until the exact field of its activity has been determined and the question settled as to whether seasonal ice shall be included. However, selections will ultimately be made from the southern countries of Argentina, Australia and India, as well as from the better known snow countries of the northern zone, where snow has become an important asset both for irrigation and for power.

THE new physics building, now under construction on the main campus of Washington University (St. Louis), has been named for Wayman Crow, who conceived and secured the charter for the university. The cornerstone was laid informally and without any ceremony on the morning of November 29. Mr. Crow showed his special interest in physics by giving $25,000 in 1875 to endow a professorship in that science. Part of the $700,000 received from two anonymous donors last summer to erect the new building and endow the department of physics will be used to enlarge and perpetuate this original fund for the Wayman Crow professorship, now held by Dr. Arthur L. Hughes.

THE centennial of the voyage of the *Beagle* will be observed next March when a group of scientific men will erect on Chatham Island, in the Galapagos group off the coast of Ecuador, a monument to the memory of Charles Darwin. The Darwin Memorial Expedition, which will erect the monument, is composed of fifteen men and two women, including scientific men from a number of universities and other institutions, under the directorship of Dr. Wolfgang von Hagen. The members planned to leave San Francisco early this month in the three-masted schooner *Golden Gate*. Their itinerary will take them down the west coast of South America, with stops at Chatham and other islands, and up the east coast of the continent. Every country except Paraguay will be visited. In addition to erecting the Darwin monument, the expedition will spend two and a half years in research, making studies in archeology, zoology, botany, ethnology and other subjects in Central and South America and neighboring islands.

AT a recent dinner attended by many engineers, the Carbide and Carbon Chemicals Corporation, a unit of the Union Carbide and Carbon Corporation, was presented with the first award for chemical achievement ever to be given to a company rather than to an individual. The award was made at the Chemists' Club, New York City, by *Chemical and Metallurgical Engineering,* published by the McGraw-Hill Company. It was given "in recognition of meritorious contributions to the advance of the industry and profession, made possible through a broader participation by the chemical engineer in the affairs of the process industries."

SUITABLE plants for home aquaria will be the feature of a special exhibit in the Museum Building at the New York Botanical Garden. Twenty or more tanks, containing both native and tropical plants in great variety, besides a number of fish, will comprise the display, which is believed to be the first of its kind ever given anywhere. It will be open to visitors on Christmas and New Year's day, and all other holidays while it is in progress. Different combinations of aquatic vegetation will be shown in the tanks, on the outside of which will be labels designating the botanical name and the place where each species of plant is native. This is being done with a special view to assist people seeking ideas for their own aquaria. Material for the exhibit, which is expected to last about three months, is being contributed by numerous growers and private collectors of aquatic plants.

IT is announced by the American Society of Municipal Engineers that work for 4,000 professional engineers will be provided by the United States Coast and Geodetic Survey, through the Civil Works Administration.

THE Soil Erosion Service, a new branch in the Interior Department operating with a $5,000,000 allotment from the Public Works Administration, is ready to proceed with actual field work of controlling soil

erosion on a number of large representative areas scattered throughout the country. The size of these demonstration areas will range from about 100,000 acres to 15,000,000 acres in the instance of the project to be undertaken on the Navajo Indian Reservation. The areas thus far selected lie in the Piedmont Plateau of South Carolina, the Black Belt of central Texas, the Palouse Wheat Belt of Washington and Idaho, southwestern Wisconsin, the Corn Belt of north-central Missouri and south-central Iowa, central Illinois and the Red Plains of central Oklahoma, with the Navajo project covering large areas in Arizona, New Mexico and Utah. Several other watersheds have been tentatively selected. On these first of the regional projects to be taken up every practical measure for controlling erosion will be used, according to the adaptability of the different kinds of land.

THE London *Times* reports that the first of a series of annual conferences was opened in Entebbe on November 23 to devise means for coordinating research work on the tsetse fly, trypanosomiasis (sleeping sickness), and general medical research in East Africa. It was under the chairmanship of Dr. Kauntze, director of the medical service in Uganda, and was attended by the directors of the medical services of Kenya and Tanganyika and the directors of the veterinary services of Uganda and Tanganyika, the director of tsetse research in Tanganyika, a medical officer from Nyasaland, and Dr. Fontana, from the Belgian Congo. The governor, in opening the proceedings, said that the summoning of these conferences had been decided on at the Governor's Conference, and their primary object was not to exchange information but to consider methods by which the knowledge of individual officials could be placed at the disposal of officials holding corresponding positions in other territories. The governor extended a special welcome to Dr. Fontana.

DISCUSSION

RAMAN SPECTRUM OF HEAVY WATER

THE Raman spectrum of heavy water has been obtained by 2,536 excitation of 8 cubic centimeters of 18 per cent. heavy water in a quartz tube 35 cms in length in contact with a quartz mercury vacuum tube. Two Raman bands were obtained with an intensity ratio of one to four, the new one having a mean wavelength of 2711 A.U. due to water molecules containing one atom of heavy hydrogen. The frequency difference was 2549, against 3420 for ordinary water. Van Vleck and Cross[1] have calculated a Raman frequency difference of 2720 for heavy water *vapor,* but a lower value is to be expected for the liquid, which Dieke has calculated as agreeing with my value within 4 per cent.

The new Raman band extended from λ 2694 to 2721 with a maximum intensity at 2711. This value is more nearly correct than the value 2713 given in a letter to *Nature* with an exposure of 16 hours. There appeared to be a slight indication of the band due to molecules containing two atoms of heavy hydrogen, but the faint continuous background made any certain measurements impossible. An exposure of 80 minutes recorded the new band with a density equal to that of the band of frequency difference 3420 made with an exposure of 20 minutes.

The heavy water used in this experiment was prepared by the electrolytic method by John W. Murray, of the chemistry department.

R. W. WOOD

THE JOHNS HOPKINS UNIVERSITY
DECEMBER 14

[1] *Jour. of Chem. Physics,* June, 1933.

BLOOD GROUPING BY MEANS OF PRESERVED MUSCLE

THE agglutinogens A and B which condition specific agglutination of human erythrocytes by the isoagglutinins α and β have been found by previous workers (by means of adsorption technique) to be present in practically every cell of the body. They also occur in solution in certain body fluids. Since they are heat stable and resist aging, they have been utilized in typing old blood stains and even in determining the blood groups of persons from the dried saliva on a cigarette butt or on the flap of an envelope.

The present writers have shown that dried human muscle can also be used for this purpose, and that even material preserved at necropsy and now several years old can be shown to contain agglutinogens in conformity to the previously determined blood groups. The technique, which has now been tested on numerous samples, can be applied to as little as 0.05 g of dried material, and it is possible for a person practised in the method to make consistently reliable determinations.

It is thought that the method might have occasional medicolegal applications, and work is now in progress to investigate if the agglutinogens can be demonstrated in mummified material, in spite of its great age. Information thus obtained might be of some value in archeology, as in identifying certain specimens. Details will be published elsewhere.

WILLIAM C. BOYD
LYLE G. BOYD

EVANS MEMORIAL
BOSTON, MASS.

CLEANING OF FRUIT CARRYING LEAD

THE rigid requirements of the Pure Food and Drug Administration have made it obligatory for fruit-growers to remove spray residues on fruits and vegetables to a point where no possible danger to the health of the consumer could develop. Within the past two years we have developed a method of using a wetting or degumming agent of certain types with hydrochloric acid, which would enable the fruit-growers to reduce the arsenic and lead residues on their produce to the required tolerance of the domestic and export markets. The results of our investigations in this field have already been reported in various publications.

More recent experiments show that these wetting and degumming agents, when used with alkalis and alkaline silicates in heated solutions increase their efficiency to a marked degree. It should be noted that, whereas the acid-wetting agent combination may be used at atmospheric temperatures, the silicate-wetting agent solution, like all alkaline washes, must be used at higher temperatures. Fruit carrying lead twelve times the federal tolerance of .02 grains per pound were satisfactorily cleaned with the silicate-wetting agent wash. The indications are that this wash solution will give satisfactory results in any type of washing apparatus which is equipped for heating the solution. The matter is one of large economic importance, particularly to fruit-growers on the Pacific Coast.

HARRY C. MCLEAN
ALBERT L. WEBER
NEW JERSEY STATE AGRICULTURAL EXPERIMENT STATION

LABORATORY FEES

FOR some time I have been considering our common plan of charging science students laboratory fees. Students entering the College of Liberal Arts, for example, are charged a tuition which admits them to any course except those in the sciences. For these courses they are charged laboratory fees. Other subjects cost the university money for libraries, lecture-room appliances, lecture and classrooms, etc., but in most institutions no fees are charged for these other than the general tuition paid by all.

The tuition paid in universities and colleges does not at all pay for the expense involved in furnishing a student with the education given him by the institution. There seems to exist an impression that a student should pay in full for the science part of his education at least so far as laboratory work is concerned.

Naturally the question is asked, Why fine a student for entering a science class? This has been emphasized by the depression, which has prevented many students from entering science work because they did not have the money to pay laboratory fees, although desiring very much to enter science classes.

I am suggesting that science teachers make a move to have the tuition charged in any school give the student admission to any class in that school, be it science, language or any other subject. The science work under this arrangement would be supported by appropriations, just as salaries are now supported or any other expense is supported.

Fifty or sixty years ago when laboratory work in science came into the colleges it was only tolerated—not welcomed. For that reason it was not permitted to have any money, and the laboratory periods must in no way interfere with regular times for classes. A typical college in 1880 to 1890 had its class periods all in the forenoon. No laboratory science was permitted to have laboratory work at any time except in the afternoons or on Saturday mornings when no classes were held in other subjects. Then, too, it was held that the laboratory work must not cost the institution anything. We are still living with part of that last century handicap in most institutions, namely, that laboratory work must not cost the institution anything and must be paid for by the students in addition to any general tuition which they may pay.

Some institutions have made a start towards doing away with laboratory fees in some sciences. In most cases of this kind the students in chemistry, for example, are required to pay for breakage slips, and during the year they really pay more for a laboratory course in chemistry than students do in other institutions where a laboratory fee is charged. This is due to the fact that the students are charged for some chemicals and other materials—not strictly a breakage charge.

I would be glad to have the reader's reaction to the proposal that laboratory fees be merged into the general tuition, and that when a student pays his tuition to enter the School of Liberal Arts or the School of Engineering or any other school he is free to enter any course given in that school. This would not abolish a breakage deposit, which money is to be returned to the student if he has not broken any apparatus—this only makes the student more careful.

I am not suggesting this as a method to get more students in science. In the University of Mississippi in some years we have more students in chemistry than there are in any other single subject. I am just proposing that science be put on the same basis as languages, history, philosophy or any other subject as far as fees are concerned. It is a proposal to give students who wish to take science an equal chance with those students who wish to take other subjects.

J. N. SWAN
UNIVERSITY OF MISSISSIPPI

EXPLORING AND COLLECTING EXPEDITIONS

APROPOS of Dr. Cockerell's very timely and appropriate remarks on expeditions in the October 27th number of SCIENCE, I should like to call attention to the wonderful opportunities for the increase of our knowledge of Cryptogamic plants, especially fungi, in the regions visited by various exploring and collecting expeditions. Unfortunately, these opportunities for some reason are usually neglected. Our present knowledge of this group of Cryptogams is very scanty and incomplete, and no very satisfactory monographic work can be done until much more material is available from the many little-known regions of the world. Very rarely do we find an experienced mycological collector included in the personnel of an expedition. Sometimes a botanist is added, but he is usually interested primarily in the flowering plants, and though he may desire to include the fungi and other lower plants, it is impossible to cover such a broad field in a satisfactory manner. A single person devoting all his time to the collection of fungi would find more than he could do in most regions, and the addition of a mycologist to a collecting expedition, even though it were a purely botanical one, would add greatly to our collection and to our knowledge of the distribution of the fungi. This should be done in the interests of economy and efficiency, as the addition of a mycologist to the personnel of an expedition would add comparatively little to the expense and would contribute much toward the advancement of our knowledge of the fungi of the world. It is to be hoped that in the interests of the advancement of this branch of science the organizers of exploring or collecting expeditions will give serious consideration to this matter.

C. L. SHEAR
U. S. BUREAU OF PLANT INDUSTRY

SPECIAL CORRESPONDENCE

THE EIGHTH GENERAL CONFERENCE ON WEIGHTS AND MEASURES

ON October 3, 1933, at the Quai d'Orsay, Paris, in the historic "Clock Chamber," there assembled, under the presidency of the Minister of Commerce and Industry of the French Republic (substituting for the Minister of Foreign Affairs, who was detained at Geneva), 48 delegates representing 29 of the nations taking part in the Metric Convention (Convention du Mètre), this being the inaugural session of the Eighth General Conference of Weights and Measures.

These general conferences have always been presented with a lengthy and diversified program. They are remarkable assemblages of diplomats and savants, exceptionally open-minded both to the necessities of international organizations and to the most complex questions of pure science. They settle these questions either by accepting or rejecting proposals submitted to them. Acceptance is sometimes made conditional, but the conferences can not give detailed study to technical questions.

On this occasion, the general conference, after having received the report of the International Committee upon the work accomplished at the International Bureau since the last session, gave its sanction to the values of all the national prototype meters whose first periodic verification has just been completed. It also approved the values of three prototype kilograms. The record of exchange of geodetic tapes between the International Bureau and various national laboratories was presented, as well as researches upon materials suitable for the formation of new standards of mass. The conference also received a statement of the studies made upon luminous radiations, but when requested to give its approval to the principle of substituting a luminous wave-length for the platinum meter bar prototype, it very prudently only consented to submit this question to the study of the international committee, in view of the complexity and controversial nature of the proposal.

A few distinct errors and editorial ambiguities, which existed in the text on international scale of temperatures, voted by the preceding conferences, were carefully rectified.

Electrical units have recently entered into the province of the bureau, which has prepared a report on their first comparisons. These have led to the expression of a mean value for the ohm and the volt with relation to the various national standards.

The conference approved an important report recommended to it by the Advisory Committee on Electricity; namely to substitute in the near future electrical units derived from the absolute CGS units in place of the "international units." In order to meet the views of the International Commission on Illumination, the conference created, in connection with the international committee[1] an Advisory Committee on

[1] The present membership of the International Committee of Weights and Measures is the following: Messrs. Volterra (Italy), *president;* Cabrera (Spain), *secretary;* Chatelain (U. R. S. S.); Guillaume (International Bureau); Isaachsen (Norway); Janet (France); Johansen (Denmark); Kargatchin (Jugoslavia); Kennelly (United States); Kösters (Germany); MacLennan (Canada); Nagaoka (Japan); Posejpal (Czechoslovakia); Ros (Switzerland); Sears (Great Britain); Statescu (Roumania); Zeeman (Netherlands).

Photometry independent of the Advisory Committee on Electricity, and comprising a considerable number of members of the special committee of the Illumination Commission. It approved the opinion that the unit of light should be based upon the radiation of a "black body," but it decided to leave to the future advisory committee the task of determining all the specifications of the same.

A request for the formation of a new advisory committee for practical metrology received favorable consideration and will be further studied.

Finally, if the reports concerning the entry of the Netherlands and Turkey into the Meter Convention (Convention du Mètre) are taken into account, the progress of the metric system in the legislative enactments of various countries will reveal the steady growth of the metric system throughout the world.

A. PÉRARD

Sous-Directeur of the International Bureau of Weights and Measures

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE SECRETARIES' CONFERENCE AND THE ACADEMY CONFERENCE

THE democratic scheme of representation by means of which the American Association embraces the wide spread of scientific activity in this country is based on the council, which is the association's governing body. The various fields of science are represented in the council in two ways: Each of the fifteen section chairmen and each of the fifteen section secretaries is a council member, and each of the seventy-four national independent affiliated societies is represented in the council. Also, geographic regions are represented; each of the twenty-seven affiliated local organizations of the academy group has a representative in the council. There are thus generally at least three ways in which any individual may have council representation: (1) Through his association section; (2) through each of the special research societies in which he is enrolled; (3) through one or more of the affiliated national organizations that are devoted to science in general (such as the Society of Sigma Xi or the United Chapters of Phi Beta Kappa), and (4) through the affiliated local organization of which he is a member (such as a state academy of science). So the association really represents many thousands of science workers and friends of science who, although not association members, are members of one or more affiliated organizations.

The association council is large and its membership is increased with each new society affiliation. Many council members are unable to attend the council sessions. These sessions are confined to the periods of the meetings and usually provide time for but little discussion. Consequently, it has come about that most questions brought before the council are not fully discussed by that body; the council depends largely on recommendations from its executive committee and it usually follows those recommendations. With only eleven members, most of whom usually attend its sessions, and with much more time than is available to the council, the committee devotes much study to questions of policy and procedure. But additional opportunity for study and discussion has been provided, in recent years, through the organization of the Secretaries' Conference and the Academy Conference.

These are really standing committees, with *ex-officio* membership, that act in an advisory capacity, aiding the executive committee and the council to reach satisfactory conclusions concerning association affairs. Each of the two conferences has a chairman and a secretary, and each holds an annual session at the time of the winter meeting of the association. Each conference secretary receives questions, suggestions and notes from his constituents and circulates these throughout his conference, by means of mimeographed "conference communications," which are sent out from time to time, under the general editorship of the general secretary of the association. With the aid of these communications and the responses thereto, the conference secretaries arrange the programs for discussion at their respective sessions. The conferences sometimes make very valuable recommendations to the council, but their greatest contributions to the welfare of the association and of the affiliated organizations are informal. They serve to crystallize opinion on many questions. Above all, they promote intercourse and exchange of thought among their members, and they facilitate cooperation among their affiliated organizations as well as between those organizations and the association. Informal contacts among conference members is further promoted, in each case, through the complimentary conference dinner (or luncheon), which is provided by the association in connection with each annual conference session.

The Secretaries' Conference includes, as *ex-officio* members: (1) The seventy-four secretaries of the regularly affiliated national scientific societies, (2) the fifteen secretaries of the association sections and (3)

the eleven members of the executive committee of the association. It brings together the persons who have most to do with the details of society and association affairs, notably with preparations for the society and association meetings. Of paramount importance is the fact that the executive officers of the association are individual members of this conference. The chairman of the Secretaries' Conference for 1933 is Professor Percy E. Brown, of Iowa State College, who is secretary of Section O. The present secretary of this conference is Dr. Mark H. Ingraham, of the University of Wisconsin, associate secretary of the American Mathematical Society.

Secretaries' communications are regarded as somewhat confidential. They are sent only to members of this conference—excepting the secretary of the Academy Conference, who receives them for his information, and sometimes individuals who are not members but who have been asked to aid the conference in some special study. Invitations to the annual secretaries' dinner are sent, by the permanent secretary of the association, to members of this conference (and sometimes to one or two invited guests) who have intimated that they will attend the conference session to which the dinner is supplementary.

The Academy Conference is similar to the Secretaries' Conference in many respects, but its membership is based on geographical distribution and local organizations rather than on representation of the various fields of science. It includes, as *ex-officio* members: (1) The twenty-seven council representatives of the affiliated organizations of the academy group (one representative from each) and (2) three representatives of the association's executive committee. The present chairman is Dr. Howard E. Enders, of Purdue University, Lafayette, Indiana, who represents the Indiana Academy of Science. The secretary is Dr. S. W. Bilsing, of the A. and M. College of Texas, College Station, Texas, who represents the Texas Academy of Science.

Academy communications are conducted like the secretaries' communications, but they are specially notable for the fact that they generally carry brief items of academy news as well as material pertaining to discussions before the conference. They are sent not only to Academy Conference members (and the secretary of the Secretaries' Conference, for his information, as well as to any specially invited guests of the Academy Conference) but also to the president and secretary of each local organization of the affiliated academy group. The Academy Conference has been especially interested for several years in high-school science clubs and the junior academies of science that have recently been organized in several states. It has done much to bring its constituent organizations closer together and closer to the association.

Each of the two conferences is to hold its annual session at Boston, in convocation week, with important topics for discussion, and the American Association will provide a Boston dinner or luncheon for each conference.

BURTON E. LIVINGSTON,
General Secretary, A. A. A. S.

REPORTS

THE WORK OF THE WEATHER BUREAU[1]

THE United States Weather Bureau through its forecasting service probably touches directly the immediate needs of more of the people of the United States than do all other federal services combined, with the single exception of the postal service. The convenience, health and budget of every family in the country are in greater or less degree dependent upon that family's ability to avoid weather hazards, exposure and loss. There is little general realization either of the extent of the personal interest of the whole population in this service or of the magnitude of the organization and the labor involved in serving this universal individual need. The significance in the life of a city, for example, of a single temperature forecast may be seen from the following: With notice of an approaching cold wave greenhouses are closed and boilers fired. Preparations are made at once by heating and lighting plants, whether gas, electric, steam or hot water, to meet the increased demands that will follow. Fire hydrants, exposed mains and general plumbing are protected. Small householders as well as large stockyards drain their mains. Gasoline engines are drained and automobile water-cooling systems are protected by the use of antifreeze solutions. Work in concrete is stopped. Street-railway companies arrange for more heat in their cars. Natural-gas companies turn a larger amount of gas into their mains to provide for increased consumption. Merchants direct their advertising and attention largely to cold weather articles. Oyster dealers increase their reserve stocks. Coal dealers supply partial orders to all customers needing fuel, instead of furnishing full orders to a few, and thus serve all their patrons. Ice factories reduce their output. The dredging of sand and gravel ceases, and iron ore piled for shipment is placed in

[1] Preliminary report of the Special Committee on the Weather Bureau of the Science Advisory Board. Members of the committee are Isaiah Bowman, Karl T. Compton, Charles D. Reed and Robert A. Millikan.

the holds of vessels, to prevent the wet masses from freezing solid. Charity organizations prepare to meet increased demands for food and fuel, and thus minimize suffering among the poor.

Again, the economic value of the agricultural forecasts in the saving of crops such as hay, corn, fruits and vegetables, through the forecasts as to the dangers from rain, drought and frosts, is already of enormous magnitude, and every increase in the reliability of these forecasts runs into large figures when expressed in dollars. In the citrus-fruit districts of California, for example, it is reported that fruit to the value of $14,000,000 was saved by taking advantage of warnings issued by the bureau during one cold wave.

The crop reporting and marketing activities of the Weather Bureau represent a service to the commercial and shipping interests of the country of a magnitude appreciated only by those who are engaged in these activities, but its benefits are felt by every one both in the price and the quality of our foodstuffs.

The railway and transportation companies make continued use of the forecasts in their shipments. Perishable products are protected against temperature extremes by refrigeration or heating, as conditions may require. Frequently shipments of perishable goods are accelerated when it is found possible to carry them to their destination in advance of expected unfavorable temperature conditions. When this can not be accomplished, goods *en route* are run into roundhouses for protection. Not infrequently an advance notice of a cold wave will hold up a contemplated shipment until after the freeze has passed, and if the cold is protracted the companies will refuse to receive consignments of goods likely to be injured by low temperatures. Cattle, as well as fruits and vegetables, are routed to avoid extremes of high or low temperature. These precautions apply in some instances to prospective temperature changes within comparatively narrow limits. Bananas, for example, require very careful handling and must be kept at a temperature of 58° to 65° F. during shipment, because a temperature below 55° chills the fruit sufficiently to cause a deterioration in quality, while a temperature above 65° will produce over-ripening.

In times of floods and other disasters it is the river and flood division of the Weather Bureau which in many instances saves millions of dollars worth of property and human lives by the hundreds through furnishing the basic information as to the precise times before which rescue agencies must do their work in order effectively to salvage property and conduct to places of safety people who are endangered.

The river and flood service is organized with its principal headquarters at the central office of the Weather Bureau in Washington, with subsidiary district centers at advantageous points on the various rivers along which a service is maintained. About 66 district centers are maintained outside of Washington.

Measurements of precipitation in the drainage basins of streams and observations of the height of water on gauges placed at strategic points are collected by telegraph or telephone from about 900 substations and serve as the basis for warnings of floods. A second useful purpose is served on navigable streams in giving notice of boating stages during the low water season.

Flood warnings are indispensable to all river industries, as well as to operations carried on in the lands subject to inundation. Their issue is followed by the removal of stock, harvested crops and other property from bottom lands, and by a general exodus of the inhabitants of the country where overflows endanger human life. Foreknowledge of expected river stages is also of great assistance in determining whether or not it will be advisable to undertake farming operations in the regions subject to overflow.

Knowledge of slight river rises is often of great value, as these frequently permit large freight movements by water. Lumbermen cut a great deal of timber in swamps and along streams during low water in anticipation of higher water to carry out their logs; advance information of coming stages enables them to have everything in readiness to carry out their work without loss of time when the favorable conditions arrive. During rising water those in charge of locks, dams and levees are alert to the need of strengthening and protecting the property under their care; exact forecasting guides their operations as to the time, place and amount of protection, or may save them from expending money and effort in protective measures that will not be required.

The Weather Bureau's service to marine navigation is of scarcely less importance than to internal commerce. Storm warnings are displayed at more than 400 points along the Atlantic, Pacific and Gulf coasts and the shores of the Great Lakes, including every port and harbor of any considerable importance; and so nearly perfect has this service become that for years few storms of marked danger to maritime interests have occurred for which ample warnings have not been issued from 12 to 24 hours in advance. The reports from the West Indies are especially valuable in this connection, in that they enable the bureau to forecast with great accuracy the approach of those destructive hurricanes which, during the period from June to November, are likely to sweep the Gulf and

Atlantic coasts. The sailings of the immense number of vessels engaged in our ocean and lake traffic are largely determined by these warnings, and those displayed for a single hurricane are known to have detained in port on our Atlantic Coast vessels valued with their cargoes at over $30,000,000.

The climatological service of the Weather Bureau is one of the most extraordinary services ever developed anywhere and probably nets the public more per dollar expended than any government service in the world, inasmuch as practically all this work is done by 4,500 unpaid "cooperative" observers to whom the bureau has furnished rain gauges and thermometers, and whom it has inspired, for the mere love of the work, to keep meteorological records and to send in monthly reports. It is the 200 regular observing stations, each presided over by a trained meteorologist and each representing about 15,000 square miles of territory, which furnish the daily data upon which the various forecasts are based, but the demand for detailed knowledge of the climate over this great area has led to the gradual development of the important and interesting climatological service. Under this service, the country is divided into 45 sections, each section covering as a rule a single state, and each having one of the regular observing stations as its section center. Alaska, Hawaii and the West Indian and Caribbean area each constitute a section. The centers collect monthly temperature and precipitation observations from more than 5,000 cooperative and other stations, and each publishes a monthly and an annual summary, giving a large amount of climatological data by months and for the year.

It is mainly these reports upon which the engineer must depend for the data which guide him in his work in irrigation, hydraulic engineering and in the vast task of planning the systems of water supply which serve practically the entire urban population of the United States. The extraordinary skill, resourcefulness and effectiveness of the Weather Bureau in organizing and maintaining this immense service at practically no cost to the taxpayer is deserving of a much larger admixture of commendation and admiration and a much smaller admixture of criticism than it receives in a recent report by a Committee on the Weather Bureau of the American Society of Civil Engineers.[2] This report is well intentioned and contains valuable information, but from the standpoint of the present committee its implications are likely to mislead the reader; first, no doubt, because the engineers' committee was instructed to confine its studies to "the service of the Weather Bureau to engineers," and since this service represents perhaps 2 or 3 per cent. of the total work of the Weather Bureau, it was well-nigh inevitable that both the writer and the reader should lose perspective in appraising the work of the bureau; and second, because the committee did not concern itself with the practical problem of the relation of service rendered to cost to the taxpayer. The report dealt largely with the placement of the instruments and the tabulation of data, but Chief Marvin in his reply has shown that not less than 95 per cent. of the instruments are actually placed as the committee recommended, while the form of tabulation of data is fixed by international usage.

The service of the Weather Bureau to aeronautics, through its aerological division, is of course new, since commercial aviation in the United States is scarcely ten years old, but the willingness of the bureau to move forward as new needs arise is attested by the fact that its aerological division is already its largest service.

As is evident from the foregoing summary of its main activities, the Weather Bureau is rendering to the public a multitude of indispensable services. Every one knows, however, that the accuracy of weather forecasting is far from perfect. Improvement in this accuracy will result in a corresponding enhancement of the value of these services. In recent years there have been developed and tested new methods of forecasting which increase this accuracy, and the remainder of this report deals chiefly with the outline of a practical plan whereby these improvements may be introduced into the United States Weather Service.

Weather forecasting in aid of aviation has developed very rapidly in Europe within the past eight years, and this has been largely responsible for the rapid development of new forecasting techniques which, however, can be applied without change to the improvement not only of aviation forecasts, but also of practically all the forecasting services. For this reason the recommendations of this report deal largely with the problem of the introduction into all the forecasting services of the United States, whether in the Army, Navy, Weather Bureau or commercial aviation, of so-called air-mass analysis methods which merely supplement rather than replace the older methods. These new methods have so demonstrated their effectiveness, both in Europe and in such use of them as has already been made in the United States, that there is the practical certainty that our whole forecasting service can be improved both as to accuracy and in reliability, if the program presented herewith is followed. So great are the interests involved, as shown by the foregoing summary of the

[2] Proceedings of the Society of Civil Engineers for January, April, May, August, September, October, 1933.

services of the Weather Bureau, that the value of the prospective, but definitely realizable, improvements in the general reliability of weather forecasts, of all types are well-nigh certain to be measurable in many millions of dollars and in the saving of a great many human lives. Through the cooperation of the Departments of Agriculture, Commerce, the Army and the Navy these improvements can easily be effected without prohibitive expense, especially since some substantial counterbalancing savings to the taxpayer will be made if the whole meteorological service, including communications, is unified under the chief of the Weather Bureau, reporting as at present directly to an officer of the Cabinet. This will involve placing on the Weather Bureau the responsibility for the transmission of all meteorological data as well as the recording and interpretation of these data. This, of course, is not intended to suggest that the meteorological work of the Army and Navy should be curtailed, since this is recognized as an essential part of these services.

The Weather Bureau serves such a diversity of interests and is of such great importance to all of them that it is clearly imperative that it have the opportunity to serve them all impartially. Subordinating it to any one of them, such, for example, as a hypothetical department of transportation, would inevitably tend to destroy its usefulness to the others. This, of course, means first, that the integrity of the Weather Bureau should be preserved in any event, and second, that the whole meteorological service should be unified under a single responsible control. This consolidation will in itself decrease costs although the expense involved in responding to the demand for an improvement in the forecasting service, so urgently demanded by aviation and also needed by agriculture, commerce and navigation, will somewhat more than absorb the savings. However, the total annual cost of the Weather Bureau service to the people of the United States has never exceeded $4,500,000 and last year's budget was only $3,200,000. In the same year the Government's appropriation to the air mail service alone was $15,000,000 and that for the extension and maintenance of the airways $6,000,000.

(To be concluded)

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A NEW METHOD FOR THE STUDY OF CHROMOSOME REARRANGEMENTS AND THE PLOTTING OF CHROMOSOME MAPS

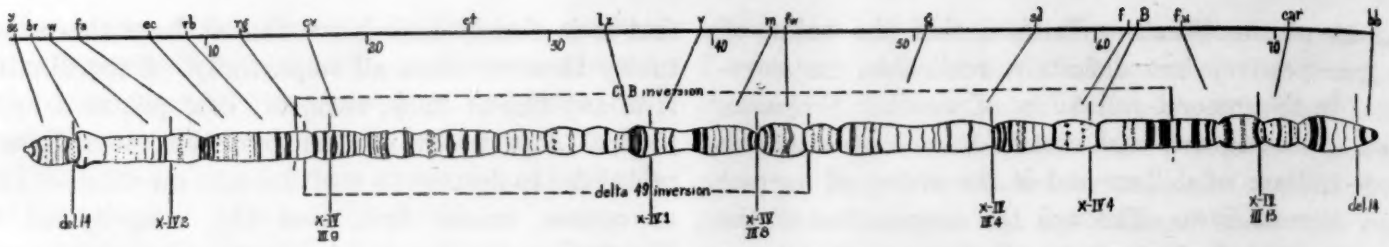
IT has long been known that in the functioning salivary glands of many dipteran larvae the chromosomes show an elongated and annulated structure. For the past year the writer has been studying such chromosomes, principally by the acetocarmine method, in larvae of *Drosophila melanogaster*. From this study the following conclusions are warranted:

(1) Each of the chromosomes has a definite and constant morphology and is made of segments, each of which has a characteristic pattern of chromatic lines or broader bands, which appear to run around the achromatic matrix. The same chromosomes, or characteristic parts thereof, may easily be recognized in different cells of an individual, or in different individuals of a species. If the position of one or more segments is shifted, by some form of dislocation (translocation, inversion, etc.), the exact morphological point (or points) of breakage can be determined and the segments identified in their new position. This discovery places in our hands, for the first time, a qualitative method of chromosome analysis and once the normal morphology of any given element is known, by studying chromosome rearrangements of known genetic character, we can give morphological positions to gene loci and construct chromosome maps with far greater exactness than has been heretofore possible.

(2) In old larvae, homologous chromosomes undergo a process of somatic synapsis. This union is more than a simple apposition, for the elements pair up line for line in the most exact way and form one apparent structure. If one of the homologues carries an inverted section we get typical inversion figures, such as we would expect in meiosis. If one of the homologues is deficient, at some point, the two mates unite except at the point of deficiency where the normal element usually buckles. Thus we can readily determine exactly how much of the one chromosome is missing. It is probable that the force which causes homologues to unite in salivary glands is the same that operates in meiosis, and while, so far as is known, these specialized chromosomes never divide, we can at least study how aberrant chromosomes unite at synapsis, a fact which should prove of great value to geneticists.

(3) In salivary glands the two arms of the v-shaped autosomes appear as independent elements with no obvious connection between them. As a result, after somatic synapsis, we find six elements in the nucleus, not the haploid number.

(4) The inert region of the X-chromosome does not appear as an organic part of this element, nor does it show in any other as yet recognized form in the nucleus. Likewise, the only part of the Y-chromo-



some which has been identified is a short piece which, morphologically, is homologous to part of the right-hand end segment of the X. This part of the X (see figure) carries the normal allelomorph of bobbed. Either the inert material of both the X and Y has been eliminated during ontogeny, by diminution or some similar process, or this material exists in the salivary nuclei in some unrecognized form not visibly connected with the chromosomes. The inert area comprises about $\frac{3}{8}$ of the volume of the oogonial metaphase chromosome.

The accompanying figure is a drawing of the X-chromosome made by uniting camera lucida sketches of various regions. Fine details are omitted. Above the figure, a crossover map having the same length as the X is shown. The symbols of gene loci, which have been located, are given together with lines showing their approximate morphological positions. The points of breakage are indicated on the X, with the name of the break given below. Thus, deletion 14 (at the left) broke the X between the loci of scute and broad. The morphological point of breakage is shown on the drawing, and, of course, scute must lie to the left of the break and broad to the right. In a similar way the position of other gene loci has been determined. Geneticists will be interested to note the morphological (and genetic) limits of the C1B and delta 49 inversions as shown by the figure, and in the close correspondence between the cytological and crossover maps.

The writer has two articles in press, one dealing with the technique and the general morphological characters of the salivary chromosome, the second, a detailed study of the X-chromosome from which the drawing herewith presented was taken. Similar studies of the autosomes have been under way for some time, and a number of students are at work on various cytological and genetic problems opened up by the new method of attack.

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PROPOSED IMPROVEMENT FOR PLANKTON NETS

WHEN plankton nets were first put to use for quantitative purposes two problems made themselves apparent. First, control of the net in regard to selection of a given operating level beneath the surface of the water without contamination of the sample from intermediate levels; second, the determination of the quantity of water filtered. The first problem was solved at an early date for vertical nets, and at a much later date (to a satisfactory degree), with some difficulty, by Kofoid for horizontal nets.

The second problem has not yet been solved to the satisfaction of planktologists, and even with the use of a complicated system of calculations, only a fair approximation to accuracy is attained. Hensen (1901)[1] developed a net which had a mouth small in proportion to the silk filtering surface in an attempt to insure the immediate filtering of all water entering the net; a coefficient of filtration was determined for various sizes of nets. The volume of filtered water was then calculated from the size of the mouth, filtering area, mesh, speed of the net, etc., these factors being subject to numerous variations and consequent corrections. However, this method, and modifications of it now in general use, does not make allowance for clogging of the pores of the net which in the case of certain types of plankton becomes an important factor.

It is the writer's desire to suggest another approach to the problem; *i.e.*, to measure the water leaving the net after it has been filtered rather than that entering the net before it is filtered. It seems that this could be done very simply by adding to the net an outside jacket of suitable waterproof material, opening at the tail into a cylinder sufficient in dimension to take a suitable type of current meter. This means that the water could enter the net in any quantity, and only the filtrate would be measured by the attached current meter, such measurement being independent of clogging. The actual volume would be arrived at by the simple equation, $F(\pi r^2)$, when F is the linear measure of the water column as indicated by the current meter.

As far as can be seen without actual experiment this method would offer no serious difficulties in development; and it is believed that it would supply more accurate data, and incur a higher degree of dependability than the methods now employed.

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[1] Hensen: "Uber die quantitative Bestimmung der kleineren Planktonorganismen und über den Diagonal-Zug mittelst geeigneter Netzformen." Wissenschaftliche Meeresuntersuchungen, Abth. Kiel, N.F. Bd. 5, pp. 69–81, 1901.

SPECIAL ARTICLES

THE PRODUCTION OF MUTATIONS BY ULTRA-VIOLET LIGHT

THE discovery by Muller that x-rays produce mutations led to the suggestion that similar forms of radiation, occurring in nature, might be the cause of natural mutations. Undoubtedly, part of the natural mutation rate is due to the radiation in question, but, as shown by the calculations of Muller and Mott-Smith, the entire rate could not be accounted for in this way. The problem was therefore raised as to what other agencies might cause natural mutations. One such possible agency is ultra-violet light, since it is known that ultra-violet light causes chemical activation. Moreover, it seems probable from the studies of Gurowitch and others that growing and dividing cells give off "mitogenetic" rays, which are in the ultra-violet region of the spectrum. It therefore seemed desirable to test the effect of ultra-violet light on the mutation rate.

Previous experiments which I did on Drosophila indicated that ultra-violet light had a slight positive effect on the mutation rate but in many of these experiments I treated the adults and it was difficult to get the rays to the reproductive cells on account of the high screening effect of the superficial tissues. I therefore decided to use the developing eggs and, in particular, eggs in which the "pole cells" were formed; that is, the germ tract cells at the time that they form a polar cap at the amicropilar end of the egg. Only the polar cap was treated, the rest of the egg having been screened (by a cover glass). A quartz mercury arc lamp was used as a source of the light. It was run at 50 volts. The eggs were at a distance of 150 cm from the lamp, and they were given 3 to 4 minutes treatment. Lethals were looked for in the X-chromosomes of males that developed from the treated eggs, and Muller's Cl B method was used for the detection of the lethals. In case any mutations were produced by the ultra-violet light at the polar cap stage, then these should appear in "bundles"; that is, in a fairly large proportion of the sperm cells. Moreover, they should be "reduplications"; that is, the same mutation multiplied. For, assume that there are 10 pole cells in the polar cap at the time of treatment and that one of the cells is struck in the right way and a mutation produced in its X-chromosome. Then roughly one tenth of the sperm cells of the adult should contain the mutation, and the male in question should transmit the mutation to about one tenth of his daughters.

Some tests already made show just such an effect. The data are as follows. From 108 males treated in the polar cap stage I got 8 cases of "reduplicated" lethals. From 110 males in the controls I got 1 reduplicated lethal.

A certain number of lethals turned up in the controls, but these were apparently lethals that occurred after the polar cap stage (that is, after treatment), and represented the natural mutation rate. For they were either not reduplicated at all, or only to a small extent, just as would be expected if they occurred at a later stage in development. The treated lot also contained these "natural" mutations. As a criterion for a lethal that was produced in a cell at the polar cap stage, I use the number of cells present in the polar cap (10 to 20) at the time of treatment. In other words, I regard as induced lethals any that are reduplicated in about 5 to 10 per cent. (or more) of the reproductive cells, and which are shown by linkage tests to be the same lethal.

On *a priori* grounds it would be very unlikely that a lethal should occur, apart from treatment, at just the polar cap stage, especially in view of the small number of cells at this stage, and the short length of time that it lasts (less than 1 hour). It is therefore very surprising that there should have been a reduplicated lethal in the controls. It is possible that the male which yielded this lethal belonged with the treated lot or that some stray light (reflected from the walls of the room) got around the sides of the plate glass that I had in front of my controls, and that it happened to strike one of the control eggs.

I wish to thank the American Academy of Science for a grant of $500 to defray the expenses of an assistant for the above experiment. I wish also to thank Miss Frances Ward for her capable assistance.

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THE IMMUNOLOGICAL RELATIONSHIP OF EASTERN AND WESTERN STRAINS OF EQUINE ENCEPHALOMYELITIS VIRUS

THE epizootic of equine encephalomyelitis which invaded sections of Delaware, Maryland and Virginia during July, August and September, 1933, has presented characteristics judged to be closely comparable with those seen in the disease as it has occurred in the West, the only apparent material difference being in a more acute course and perhaps greater mortality. Epizootiologically, the diseases have much in common and the syndromes do not differ, except as above noted.

The anatomical changes observed at autopsy have been confined largely to the central nervous system and have not been uniformly different from those seen in cases of the western disease.

The histological alterations appear to differ only in degree, the eastern disease exhibiting a more intense small cell infiltration, and a more marked extravasation of erythrocytes and fluid into the perivascular and pericellular spaces.

The writers have isolated eight strains of a filterable

virus from cases in Delaware and Maryland, and one, a Maryland strain designated Md[1], has been compared in preliminary tests with a South Dakota strain of virus designated S. D., which was isolated by the writers[1] in 1932. Neutralization tests, utilizing a hyperimmune horse serum and a hyperimmune rabbit serum, were conducted with the two vira. The horse serum was prepared by Dr. C. M. Haring *et al.*, of California, through the use of California strains of virus, while the rabbit serum was obtained by the writers, who utilized the South Dakota virus. Both sera had previously been repeatedly shown capable of neutralizing California virus as furnished by Dr. Haring, the S. D. virus and a second strain of South Dakota virus[2] which we recovered from a case occurring during the present 1933 outbreak.

The technique of preparing virus suspensions, mixing and holding serum-virus inocula, was identical to that employed by Howitt[3] in neutralization tests of poliomyelitis and equine encephalomyelitis vira.

A series of three tests was conducted, using S. D. and Md[1] vira on the same days, with controls in the form of normal serum-virus mixtures and saline-virus mixtures of the same virus dilution as that in the immune serum-virus mixtures. The guinea-pigs were inoculated intracerebrally after trephination. In each of the tests applied, the serum completely neutralized the S. D. virus as judged by failure of any inoculated animals to show any signs of illness during an observation period of ten days. Normal serum-virus and saline-virus inoculated guinea-pigs died or developed a moribund condition warranting destruction on the fourth to sixth day. No guinea-pig inoculated with mixtures of Md[1] virus and the above immune sera survived for more than four days (some moribund animals were destroyed on the third or fourth days). Likewise animals inoculated with normal serum and saline control mixtures containing the same dilution of virus succumbed in a manner typical of previous passage inoculations of the same virus.

Two further tests using two volumes of immune serum to each volume of Md[1] virus of the same dilution as previously employed failed to demonstrate neutralization of the virus. As an additional check two tests using three volumes of serum to each volume of Md[1] virus likewise gave no indication of virus neutralization or even partial inactivation. Indeed, in some instances the serum appeared to cause an increased virus activity as evidenced by a shortened incubation period.

With the Md[1] strain of virus well-marked symptoms were often evident on the second day following intracerebral inoculations and death ensued on the third or fourth day after a syndrome indistinguishable from that of the S. D. virus disease.

Of a group of four guinea-pigs which had been shown by at least one intracerebral inoculation to be immune to S. D. virus, two were inoculated intracerebrally with Md[1] virus and two were exposed in the same manner to S. D. virus. The two animals inoculated with the S. D. virus survived without any signs of illness, while those inoculated with Md[1] virus succumbed. Controls inoculated with each virus developed typical encephalomyelitis and succumbed or were destroyed upon reaching a moribund state.

A guinea-pig virus brain (Md[1] strain) was ground in a mortar with sand and saline and centrifuged at 1,000 r.p.m. for 20 minutes. The supernatant fluid was further diluted and guinea-pigs were inoculated intracerebrally with 0.2 cc of dilutions varying from 1:100 to 1:20,000. Those animals which were inoculated with a dilution of 1:7,000 and lower succumbed while those which received dilutions greater than 1:7,000 survived without evidence of illness.

Titrations of S. D. virus similarly prepared have disclosed a M. L. D. of 0.2 cc of a 1:2000–1:5000 dilution, depending upon the particular sample tested.

While anti-serum of the Md[1] type was not available at the time these tests were made, our preliminary observations indicate that the Md[1] virus recovered from the current outbreak of encephalomyelitis in the central Atlantic coast states is not identical to the western virus as exemplified by the S. D. strain. The Md[1] virus disease in the guinea-pigs is of a more acute type than the S. D. virus infection and the vira show certain immunological differences.

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[1] This strain of virus, referred to in SCIENCE, Vol. 78, 2012, pp. 63–64, 1933, was recovered from a specimen submitted by Dr. C. H. Hays, inspector in charge, B. A. I. field station, Pierre, S. Dak., who conducted extensive field studies of the 1932 outbreak in South Dakota.

[2] Recovered from specimen submitted by Drs. C. H. Hays and C. C. Heacock, collected during the 1933 outbreak in South Dakota.

[3] B. Howitt, *Jour. Infect. Dis.*, Vol. 51, No. 3, p. 493, 1932.

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